More Sky and Trees, Less Steel and Wire

by Craig Canine for NRDC's "On Earth," Summer 2004 issue

You've never heard of Vickie VanZandt, but the chief engineer of the Pacific Northwest grid is trying to bring America's creaking electrical transmission system into the twenty-first century -- while conserving energy and preserving the lush landscape.

Vickie VanZandt was planting azaleas in her garden on August 10, 1996, when the phone rang. "It was a Saturday afternoon, and really hot," she recalls. Her hands were covered with a mix of dirt and sweat as she picked up the receiver. She recognized the voice of one of her employees, a normally unflappable dispatcher who worked in the transmission control room of the Bonneville Power Administration (BPA) in Vancouver, Washington. He was practically shouting into the phone.

"We've got a problem," he said. "The interties have gone down!" The interties are an 846-mile-long, 500,000-volt system of power lines linking hydroelectric generators on the Columbia River to southern California. They are also one of the biggest electrical transmission pipelines in the United States.

"We were sending a lot of power to the south through the interties -- 7,400 megawatts," enough electricity to supply more than seven million homes, VanZandt explains. "And my operator tells me they're totally out of service. At first, we didn't know what had happened," she continues. "The first report said it was sabotage. But then we learned the whole thing started when some of our power lines sagged into a few overgrown trees. We put the lights out at the Republican National Convention in San Diego! More than 10 million people lost power. It was horrible," she says, wincing at the memory.

As she recalls the day's events, VanZandt stands near a map of the North American power grid. The map, showing a venous network of 200,000 miles of high-voltage transmission lines, is divided into three distinct sections, known as interconnects. The largest is the Eastern Interconnect, which covers two-thirds of the continental United States and Canada, from the Atlantic coast to the Rocky Mountains. The Western Interconnect, also huge, extends from the Rockies westward to the Pacific. And then there's Texas, which has a comparatively small interconnect all to itself (the slogan "Don't mess with Texas" apparently extends to the realm of electrical infrastructure). VanZandt runs a good-size chunk of the Western Interconnect in the Pacific Northwest.

As vice president of transmission operations and planning for the Bonneville Power Administration, she bears direct responsibility for 15,000 miles of transmission lines and about 250 substations spread across an area larger than France. This territory, in which the BPA transmits and sells the electricity generated predominantly by 31 federally owned hydroelectric dams and one nuclear plant on the Columbia River system, covers all or part of eight western states: Idaho, Washington, Oregon, western Montana, and small chunks of Wyoming, Utah, Nevada, and northernmost California. The 1996 blackout demonstrated that a seemingly trivial event on VanZandt's turf can have consequences that ripple far beyond it. In a variation of the fabled "butterfly effect" from chaos theory -- the idea that the flap of a butterfly's wings in Brazil could set off a tornado in Texas -- the modern electrical grid provides proof that a filbert tree in remote western Oregon can disrupt a convention of Republicans in San Diego.

It was with a sense of déjà vu, therefore, that VanZandt learned about the events leading up to last summer's blackout on August 14, the worst power outage in North American history. It, too, was triggered by a few errant tree branches on a hot summer's day. Her experience with major grid disruptions in 1996, and the aggressive steps she had taken since then to see that such a thing would never happen again in the Pacific Northwest, made her a natural choice to serve on the technical team that investigated the causes of the 2003 blackout, which left 50 million people without electricity, from Detroit to Toronto to New York City.

The North American power grid -- the infrastructure upon which all others rely -- may be one of the supreme engineering accomplishments of the twentieth century, but most of it was designed in the 1950s and 1960s and built before the era of the microprocessor. As last summer's blackout demonstrated all too starkly, the grid is showing its age. The Bush administration, members of Congress, and the power industry have all advocated building more and bigger power lines. This approach -- let a thousand towers of steel bloom -- is also typical among VanZandt's colleagues, the electrical engineers who operate and maintain the grid.

But Vickie VanZandt is hardly typical. She breaks the mold in at least two ways. First, she's the über-linesman of one of the largest power-line systems on the continent, and she's a woman -- one of the few to hold such a prominent engineering position in the transmission industry. Second, and more consequential for the awe-inspiring landscape of the Pacific Northwest, she understands that power-line corridors cut ugly scars across the face of the land. Building new ones turns long swaths of wildlife habitat into linear construction sites, with all the attendant clearcutting of trees, construction of access roads, erosion of soils, and siltation of waterways. This, she believes, should be done only when other options are exhausted. She's unique among the nation's highest-ranking transmission engineers in supporting something known around the BPA as "non-wires solutions" -- ways of squeezing better performance from the grid without throwing more steel and aluminum in the air.

"You've got to keep in mind who we're serving here," VanZandt says. "The Northwest isn't just a place, it's a lifestyle. Folks here like their coffee, they like their clean air, they like their fish, and they like their beautiful mountains. So, environmentally, you want to have a light footprint. You don't want to carve through these pretty green trees if you don't have to."

VanZandt is a soft-spoken, engaging woman of 50 with round features and silver-blond hair that falls to her shoulders. She grew up a tomboy among the rolling wheat and onion fields of Walla Walla, in eastern Washington. She was fond of playing with Erector sets, and derived great joy from taking apart and putting back together household gadgets like electric clocks and radios, to see how they worked. An enthusiasm for both math and machines eventually led her to major in electrical engineering at the University of Washington in Seattle, where she was one of only two women in a class of more than 500 engineers. In spite of the overwhelmingly male milieu, she didn't feel terribly out of place. This is a woman who rides a Suzuki Bandit 1200 -- a powerful rocket on two wheels. "Sometimes," she laughs, "I like to ride it to work and shock the guards."

VanZandt brings an almost childlike sense of wonder and delight to her job as chief grid operator for the BPA. "Yeah, I'm a geek," she says with a grin. Looking out a window near her office in the Dittmer Control Center, a sixties-style concrete edifice in Vancouver, she gestures at the towers that carry high-voltage lines to a substation 100 yards away. "It's like a big Erector set. Isn't it cool?"

We walk through a broad, red-carpeted corridor in the Dittmer building and pause to examine a display that sits on the floor. It looks like modern sculpture, but it's part of a transmission tower -- a single support arm made of rigid gray insulating rubber, about five feet tall. A metal hand at one end of the arm grasps a three-foot-long sample of high-voltage power line. It's almost as thick as my wrist. "That's ACSR cable -- aluminum conductor, steel reinforced," she explains. "We wouldn't want to be this close if it were a real, energized power line. If you get within six feet of a high-voltage line at 500 kilovolts, it will flash over to you. It can be deadly business, working around this stuff." I step back, and we keep walking.

We go down some stairs and across a hall, where VanZandt unlocks the door of a small auditorium, a room with a concrete floor and walls and banked rows of comfortably padded seats. She's going to show me a PowerPoint presentation that explains the events that led to the blackout of August 14, 2003. But first, she gives me a quick lesson on how the grid works.

The three interconnects that make up the North American electric power system, she explains, are linked in a few places, but for the most part they are electrically independent. Each interconnect is a big network of wires that connect the major parts of the system with each other. At one end there are power plants. Most plants have multiple generators, which are rotors with magnets that spin inside coils of copper. This mechanical rotation generates alternating current (AC) -- a flow of electricity that changes magnetic poles at a particular frequency. In North America, that frequency is set at a standard 60 cycles per second, or 60 hertz (Hz). A generator can be made to rotate in any of several ways: by water flowing through the penstock of a hydro dam, by wind blowing an impeller, by steam created from heating water with a coal furnace or nuclear reactors, or by huge internal-combustion engines that burn diesel fuel or natural gas.

Electric current is like water in the pipes of a plumbing system; voltage is akin to the pressure that pushes the water through the pipes. The big electrical "pipes" that originate at power plants are transmission lines. Mounted on tall steel towers that march across the landscape, these lines carry gushers of current over long distances at high voltages, from 230,000 volts (230 kilovolts, or 230kV) up to a million volts. A network of 500kV transmission lines forms the backbone of the grid in the Pacific Northwest.

These electric superhighways deliver power in bulk from generators to substations, which are scattered throughout areas of high demand. Substations are the system's exit ramps. They contain transformers that step down the voltage to "sub-grid" levels as well as industrial-size switches and circuit breakers that can shut down lines if they become overloaded. Substations feed into a network of smaller wires that deliver power to its ultimate users. These smaller wires, usually suspended on wooden poles, are known as the distribution system.

Electricity is the most ephemeral of commodities. It can't be stored economically in large quantities, so it's consumed the moment it's created. Moving at close to the speed of light, electric current zips along the path of least resistance from a generator, through the transmission and distribution network, to the blender and coffeemaker on your kitchen counter. Engineers like VanZandt call anything that consumes electricity a load.

The main challenge in running a power system is balancing supply with demand -- matching generating capacity to load. Demand for electricity changes constantly, although it tends to follow fairly predictable patterns from hour to hour, day to day, and season to season. Working from demand predictions, engineers schedule power plants to increase or decrease their output by activating or idling individual generators. Human dispatchers working in control rooms can call for more or less power generation as needed to maintain balance. If there's more power flooding onto the grid than is being consumed -- or if a series of downed power lines severs the ties between a generating plant and a major load center, such as Cleveland on a steaming-hot summer day -- then bad things start to happen. Voltages drop and current starts sloshing around the grid like oil in a supertanker. Generators, which are designed to rotate in lockstep with all the other generators on the interconnect to produce a steady 60 Hz, can get out of sync. They speed up or slow down, causing vibrations that will, if unchecked, damage turbine blades, rotors, and other equipment. To prevent costly damage, relay sensors will shut down lines, generators, and entire power plants if things get hairy on the grid. And that's when the lights go off.

August 14, 2003, started out as an ordinary day," VanZandt says in a soothing voice as she switches on the projector. A map showing the transmission lines around Cleveland flashes onto the screen. "It was hot in the Midwest -- middle to upper 80s -- but nothing really out of the ordinary for August." Operators in the control room of FirstEnergy, a large utility company based in Akron, 40 miles south of Cleveland, saw nothing unusual on their computer screens.

But appearances would be deceiving in the FirstEnergy control room that day. A computer malfunction had disabled the alarm system that would have signaled problems on the grid. And sure enough, problems began to develop. At about 3:05 p.m., a 345-kilovolt line southeast of Cleveland sagged into an untrimmed tree and tripped out of service. "When you lose transmission through one line," VanZandt says, "the current it had been carrying instantly seeks another path. It takes a detour over other lines, putting a heavier burden on them." The more juice a line carries, the hotter the line gets; the hotter it gets, the more it expands and sags. A combination of high temperatures, no wind to cool off the lines, and lax tree-trimming swiftly took its toll. Two more lines serving the Cleveland area heated up, touched trees, and tripped out.

The loss of three high-voltage lines sent a surge of current through the network of lower-voltage distribution lines in the Cleveland-Akron area. These smaller lines started to overload and trip out, one by one, until 16 of them were gone. At 4:05, one hour after FirstEnergy lost its first line, a key high-voltage pathway called the Star-Sammis line overloaded and tripped out. "Then the dominoes started tipping over," says VanZandt. "Until then, it was a local problem in northern Ohio. But after the Star-Sammis line went, the whole Cleveland area was shut off from its usual supply source. There was plenty of generation, but no transmission to get it there. The resulting overloads started an unstoppable cascade. At that point, it was game over." By 4:12 p.m., the cascade had played itself out. More than 500 generating units at 265 power plants had gone down; it would take several days to get them all started again. "I've never seen a power system get that far out of control," says VanZandt. "It was one for the textbooks. They'll be reading about this in 100 years."

"Could it happen here?" I ask.

"No, I don't believe it could. And here's why." VanZandt strides purposefully to the front of the auditorium and pushes a small button. With a motorized hum, a line of tan burlap drapes covering the front wall slowly opens, revealing a giant picture window with a second-story view down onto a room the size of a large gymnasium. Arrayed across the brightly lit floor are seven doughnut-shaped desks. A person sits in the hole in the middle of each massive wooden doughnut, surrounded by a dozen computer monitors. At one end of the room, a two-story map blinks and pulsates like a billboard in Times Square. Ten casually dressed transmission operators (including two women) look up from their high-tech workstations; they all smile and wave. VanZandt waves back. "I'm so proud of these guys," she says, beaming down at her crew. "They're the best in the business. This is the O'Hare Airport of transmission control centers. We process more energy transactions here than anyone else -- up to 2,500 per day."

I ask her what kind of energy transactions. "Contracts for power transmission on our system," she explains. "Let's say there's a power plant in the northern Cascades that has 100 megawatts of surplus power. Under deregulation, they're free to sell it on the open market. A utility in Southern California might agree to buy it. So the generator in the Cascades would contract with us to use 100 megawatts of transmission capacity to carry power from its plant to the Pacific intertie, which connects our system with Los Angeles.

"Before deregulation," she adds, "every utility company built its own generating plants and the transmission lines it needed to serve its own load centers. Now it's wide open. Deregulation has changed the flow of power across the system. It's made their jobs" -- she gestures toward the people in the control room -- "much more complex. We've got to keep track of all those transactions and make sure we don't overbook the system."

FirstEnergy tried to duck responsibility for the August 14 blackout by blaming it, in effect, on deregulation. The utility claimed that high-power flow patterns across northern Ohio -- circumstances beyond its control -- made conditions on the grid precarious. That excuse simply won't wash, VanZandt says. "It was a normal summer day," she stresses -- until power lines started frying the treetops.

I ask her what could have prevented it. Trimming the trees, she replies, without missing a beat. Better tools to monitor the system would have helped as well. "At FirstEnergy they didn't have a map board," she says, motioning toward the enormous blinking billboard in the control room. "When a relay trips out a line on our system, operators hear an alarm and see lights flashing on the map. Probably the biggest thing I added to the control room after 1996, though, was that desk." She points to one of the computer atolls below the viewing window. The Remedial Action Scheme, or RAS, desk is a high-speed electronic monitoring and control tool that detects imbalances on the grid and reacts much faster than a human operator could. "That keeps small problems from cascading into big ones."

VanZandt is too modest to say so, but other people familiar with the power business see her response to the 1996 outage as a model for the kind of leadership that's needed to bring the entire electrical infrastructure of the country into the twenty-first century. "She's got remarkable vision," says Nancy Hirsh, policy director of the nonprofit Northwest Energy Coalition, a BPA watchdog. "She has an extraordinarily comprehensive view of the role of transmission in the overall picture of energy policy, conservation, and environmental stewardship. That's an unusual trait in a transmission engineer."

The "vision thing" has, in some ways, been forced upon VanZandt. Her tenure as the BPA's chief grid engineer has coincided with one of the most tumultuous periods in the organization's history. Founded in 1937 as one of Franklin D. Roosevelt's New Deal work programs, the Bonneville Power Administration is an agency of the federal government under the Department of Energy. It is not tax-supported; rather, it funds itself by marketing power from the federal hydro dams on the Columbia River, the Columbia Generating Station nuclear plant at Hanford, and several smaller power plants. It sells this power at cost to wholesale customers, most of which are public utilities in the Northwest. These wholesale customers, in turn, market the power at retail rates to homes and businesses. The BPA also operates three-fourths of the region's high-voltage transmission grid and collects fees from utilities that use the grid to transmit power of their own. When the BPA's expenses exceed its revenue, it borrows money from the U.S. Treasury, which it must repay with interest.

Since VanZandt's promotion to her present position in 1996, the BPA's financial condition has been uncertain at best. Droughts from the late 1990s through 2001 led to low water levels on the Columbia. The hydro dams in the BPA's system couldn't generate enough power to meet all its commitments. A scarcity of power to sell, combined with some poorly timed contracts to buy power at exorbitant prices, put a giant dent in the utility's finances. It went deeply into debt and retrenched, slashing costs and curtailing long-planned capital investments in its transmission system.

VanZandt and her colleagues had to be both frugal and selective in making improvements after the 1996 debacle. Their first move was to get tough on overgrown trees in their transmission corridors. The day after the blackout, she says, "not only did we have chain saws out, we had bulldozers pushing filbert trees over. We took out 6,000 trees within a couple weeks." The number of tree-related power outages dropped from 42 in 1996 to 2 in 2003. To illustrate the point, VanZandt shows me before-and-after photographs of a double row of high-voltage towers in the Midwest. The first shows silver cables suspended within zapping distance of leafy treetops; the second shows a 300-foot-wide strip of brown, denuded ground. "I know the scorched earth isn't pretty to most people," she says, "but that's what I call a beautiful power line right-of-way."

Even the most zealous onslaught of chain saws and cherry pickers can go only so far toward fixing what ails the grid. Like the North American electricity infrastructure as a whole, much of the BPA's transmission system is something of an industrial-age relic, badly in need of a technology makeover. If the power-delivery system can be thought of as a vast circulatory system of arteries and veins, then what's needed to bring it into the twenty-first century is a parallel nervous system that can sense, process, and relay vital information throughout the network. New power lines might aid the circulation of electricity in localized pockets here and there, but VanZandt and her fellow BPA transmission experts wanted to make more sweeping, system-wide improvements. That meant adopting new technologies to infuse new life into aging transmission lines.

The RAS system that VanZandt added is one such technology. The BPA also installed a set of gadgets called Flexible AC Transmission Systems, or FACTS. Unlike old, mechanical power switches, these solid-state switches resemble the microelectronic switches and routers used in computer networks, but are heavy-duty enough to handle hundreds of thousands of volts. Coupled with the computer brains needed to operate them intelligently, FACTS devices can respond to changes in power flow and voltage on the grid, making necessary adjustments in milliseconds. All these electronic components can exchange information at the speed of light, thanks to $160 million worth of new fiber-optic communications gear -- money well spent, even for a cash-strapped agency.

VanZandt does not embrace every new technology. She's wary, for example, of superconducting cables -- ultra-low-resistance conductors that can carry up to five times as much juice as ordinary lines. "What happens if one of those super-fat pipes goes down? You'd lose *mega* watts," she says emphatically. "All that current suddenly jumping onto another path would melt down everything around it. So if you have one superconducting transmission line, you'd better have a spare one right next to it." And that, she adds, would be super-expensive.

VanZandt favors technologies that add resiliency to the grid. She points to one example visible from a window at BPA's transmission headquarters. Through the misty precipitation so typical of the region (VanZandt refers to it, fondly, as "liquid sunshine") I can see several rows of stacked modules in the nearby substation that look a bit like giant steel beehives. "Those are called shunt capacitors," she explains. "We added a bunch of them after 1996. They're like the shock absorbers on your car that damp out the vibrations after you hit a chuckhole." The capacitors store and release energy, she says. In concert with other features they act as shock absorbers for the grid.

Thanks to such high-tech innovations -- shunt capacitors, RAS, FACTS, fiber-optics -- the BPA managed to avoid building major new transmission lines for more than 15 years. But the construction moratorium couldn't last forever. During the 1990s, the Northwest's population, concentrated mainly along Interstate 5 from Seattle down to Portland, grew at a rate faster than India's. In 2001, VanZandt and her transmission planners put together a list of 20 major projects that would be needed over the following 10 years to relieve expected bottlenecks, or heavily congested pathways, in the BPA's grid. They also commissioned an independent study to evaluate the 20 proposed projects and suggest which, if any, might be candidates for what they called "non-wires initiatives" -- alternatives to building new lines.

This move ruffled some feathers among the old guard at the BPA. "Most people in the transmission business are used to the old way of doing things," says Carolyn Whitney, the agency's vice president of transmission business strategy and public affairs. "The traditional mind-set is 'You've got a congested transmission path -- so condemn the land and build the sucker.' Suggesting that there might be other approaches to solving the problem is seen as a bit radical."

The "radical" contingent at the BPA went a step further. They set up an advisory group called the Non-Wires Solutions Round Table. The prime movers were Whitney and Brian Silverstein, the BPA's acting vice president of transmission planning, with VanZandt as an enthusiastic executive sponsor. They recruited a heterogeneous group of 18 of the Northwest's leading energy experts, including regulators; non-BPA utility officials; environmentalists such as Ralph Cavanagh, codirector of the energy program at the Natural Resources Defense Council; and executives from large industry power customers, such as Boeing. The group met four times in 2003 to work out an entirely new process for planning improvements to the grid. Instead of assuming that new construction is the best solution to every problem, they evaluate other ways of relieving congestion, such as energy efficiency programs; pricing strategies to reduce peak demand; and distributed, or localized, generation (including wind and solar power) so less long-distance transmission is needed.

Sometimes, putting aluminum and steel in the sky is the best way to go. VanZandt "is not about to make a decision that undercuts the BPA's responsibilities, nor is she taking risks with the grid," Cavanagh says. "When she can't find an alternative to building a new line, she damn well builds it." This past winter, in fact, the BPA finished constructing its first new transmission line since 1987. The 500kV line, known as the Kangley-Echo Lake project, crosses the Cedar River watershed, just east of Seattle. To prevent heavy equipment from tearing up the watershed, which supplies Seattle's drinking water, construction crews used helicopters to fly out felled logs and fly in new 135-foot-high transmission towers. Without the new line, computer modeling showed that the Puget Sound area would be vulnerable to blackouts.

In other cases, careful analysis may reveal that building a new line is not the best answer. One of the congested pathways the Non-Wires Round Table is examining closely is on the Olympic Peninsula, west of Puget Sound. Demand forecasts show that the existing transmission line running from Olympia to the town of Shelton -- a distance of about 15 miles through forests of Douglas fir and spruce -- may be too small to handle peak heating loads on the peninsula in coming winters. Reinforcing the pathway by clearing a wider corridor, erecting new towers, and stringing up high-voltage cable would cost more than $30 million -- all to provide capacity for a peak energy demand that lasts for only several hours a year. Perhaps it would prove cheaper to exploit generating resources already on the peninsula. Locally generated power wouldn't have to pass through the skinny straw between Olympia and Shelton.

The BPA has several large customers on the Olympic Peninsula -- utility companies, paper plants, a shipyard operated by the U.S. Navy -- that have their own generators. They use these generators only for backup power during emergencies, however, because it's cheaper to buy electricity from the BPA (electricity that comes through the Olympia-Shelton line). But what if the BPA paid them enough to run their generators profitably (or at least on a break-even basis) during the few hours a year when peak demand threatens to exceed the capacity of the Olympia-Shelton line? Lopping the tops off the demand peaks would make a new line unnecessary, at least for a while.

Matt Samuelson is a key player in a Round Table pilot program that is testing this tantalizing possibility. His title is power supply engineer at Mason County Public Utility District (PUD) #3 in Shelton. He supervises a little five-and-a-half-megawatt generating plant fueled by natural gas, which PUD #3 built a few years ago when a shortage of power from the BPA's hydro dams forced the utility to buy electricity from other sources at brutally high market prices. It ran the plant for about 18 months, until higher water levels on the Columbia ended the BPA's shortage. Now the plant sits idle most of the time, so Samuelson and his colleagues at PUD #3 were persuaded to sign up for the pilot project.

The day before the BPA anticipates a big demand peak, dispatchers use a designated Web site to put out a request for generating capacity from customers in the program. It's up to Samuelson to respond to these requests on behalf of PUD #3. "Last Friday," he explains, "the BPA dispatchers put out a bid for Monday, for a four-hour block from 6 a.m. to 10 a.m. Let's say they bid $130 per megawatt-hour. But $130 won't cover our costs, so we say we'll do it for $145 a megawatt-hour. If they accept our counteroffer, then we fire up the plant for those four hours on Monday. We don't put the power on their grid; we consume it ourselves. But that's five less megawatts they have to dispatch over their transmission line."

There have been a few glitches, but for the most part, the pilot project has gone reasonably well. The main challenge, as with so much else concerning the grid, is reliability. The BPA's Brian Silverstein explains: "We have to get our dispatchers to feel comfortable that when they call for power from those generators on the peninsula, it will come. They have to be just as confident in the non-wires solutions as they would be if we built more lines."

Enrollment in the pilot project already represents a 22-megawatt reduction in peak demand, "enough to defer the project for a year," Silverstein says. "If you can put off a $25 million capital cost for even a year, that's worth a lot." And waiting, he says, may save more than just money. "Technologies may come along that will make that line no longer necessary."

The Non-Wires Round Table is still fairly new, but it has started to attract attention from other grid operators, planners, and regulators around the country. In the sometimes acrimonious debate about what should be done to prevent a repeat of last summer's grid collapse, it shines as a model of civil discourse and enlightened action. "It's a remarkably collegial group, especially considering the diversity of perspectives," says Mike Weedall, the BPA's vice president of energy efficiency. "You have representatives of large industrial utility customers and investor-owned utilities sitting down with environmentalists and public-utility commissioners," he adds, wide-eyed, as if he'd personally had a glimpse of the peaceable kingdom.

Vickie VanZandt -- one of the chief knights of the BPA's extraordinary round table -- couldn't be more pleased. "It seems like the last few times we've met, there's been magic in the air, like somebody sprinkled a little pixie dust," she says. "We realized that there's hope that we can overcome some institutional barriers and get to the right societal solution -- the solution with the least cost and lightest footprint. I am really optimistic about what we can accomplish in the future. It's going to be a pretty neat journey for us." With the help of forward-thinking engineers like her -- and maybe a little pixie dust -- the grid of the future could be green, like the trees bathed in liquid sunshine just beyond the power lines outside her window.