O'DONNELL His enthusiasm is "borderline wacko," says an admirer

Solar's Day in the Sun

The big hurdle has been finding a technology that can match the low cost of fossil fuel. John O'Donnell thinks he has that licked

BY JOHN CAREY

JOHN O'DONNELL STARTED THINKING about saving the world 30 years ago. In his first job, in the late 1970s, he worked to harness fusion—the nuclear reaction that powers the sun—at Princeton University's famed Plasma Physics Lab. "The sense was, if it was successful it would change the world," O'Donnell recalls.

It wasn't successful. O'Donnell moved on. Over the years, he started companies that made supercomputers and semiconductors. He lived out of suitcases, raised scores of millions for his companies, and had three kids. But when his Campbell (Calif.) chipmaker was

PHOTO ILLUSTRATION BY MEL LINDSTROM

sold and its operations moved to Shanghai last year, the recently divorced O'Donnell jumped off the roller coaster. "I told myself: 'I have a year to figure out if there is something I could do that would be of use,'" he says.

He's convinced he has found that something. The idea is to slow global warming and cure the planet's energy woes, not with plasma or windmills or "clean" coal smoke, but with mirrors. Miles and miles of mirrors, to be exact, focusing the rays of the sun onto pipes to heat water to run hulking steam turbines. This so-called solar thermal approach would mean no emissions that cause global warming. No worries about radioactive waste. No need for coal power, which faces increasingly hostile scrutiny. Not even much need for oil, if plug-in hybrid cars like the Chevrolet Volt start to replace gasoline burners. "I want people to have it in their heads that there is a solution—and it doesn't even mean raising their electric bills," he says.

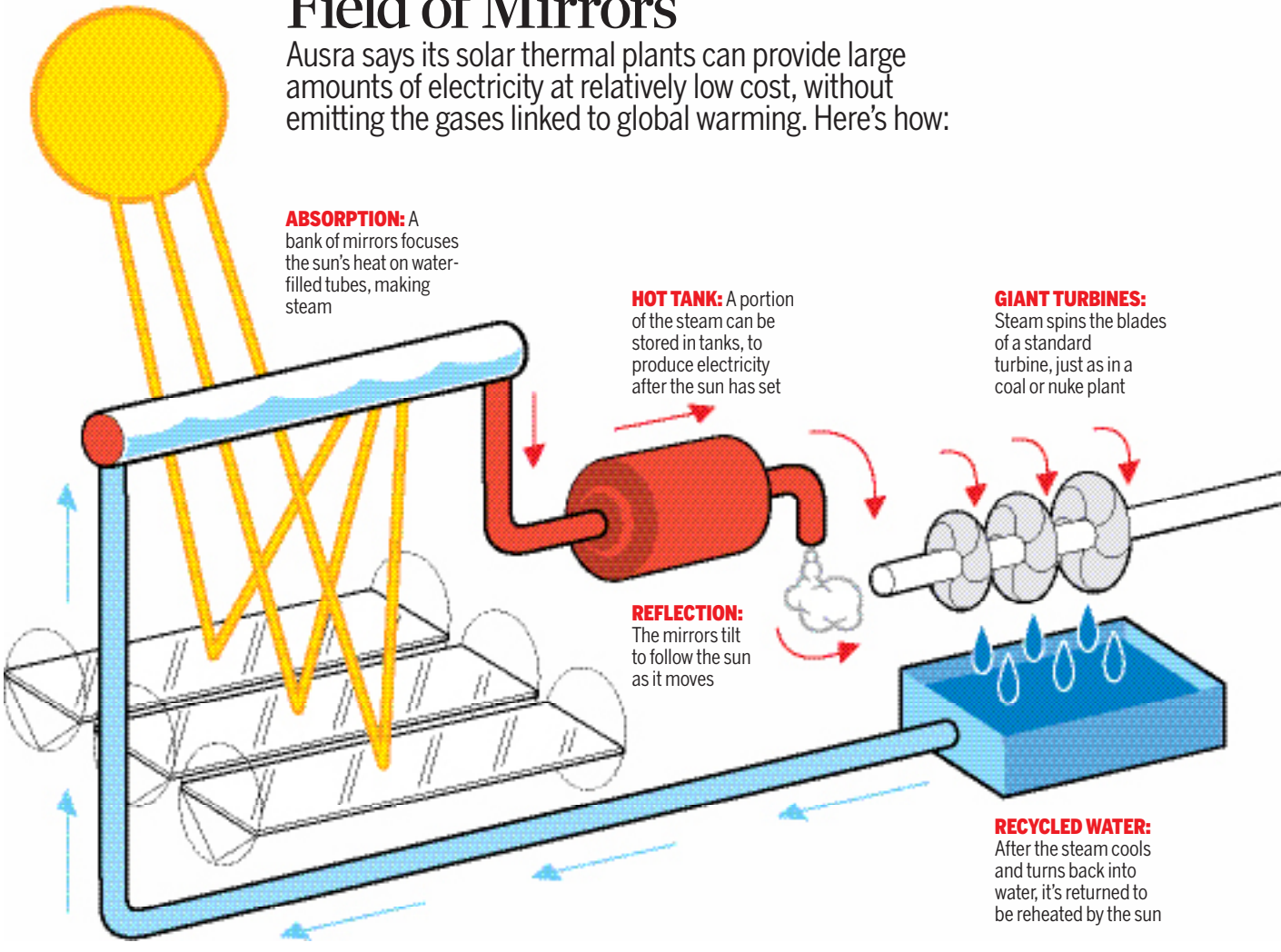
A fantasy? Maybe. The big question is not whether solar thermal plants work, but how much the electricity will cost. Right now, the price for existing mirror and steam turbine systems is about half that of the more familiar photovoltaic (PV) panels, which use sheets of semiconductors to convert sunlight to electricity. But that's still nearly twice as much as a new coal plant. O'Donnell believes the technology he plucked from obscurity in Australia will be cheaper—although he has to prove it. And assuming his plants get built, transmitting power from desert to cities will be a challenge. "Big Solar is a dream," says Michael G. Morris, CEO of American Electric Power, the nation's largest user of coal. "Is the land there? Yes. Is it practical now? I don't think so."

GODZILLA PILOT

EVEN HIS FANS sometimes find O'Donnell's passionate pronouncements extreme. "His enthusiasm and maniacal commitment to this is borderline wacko," says admirer Roger Clark, air and energy director at the conservation group Grand Canyon Trust and a supporter of solar thermal power. Yet O'Donnell has already moved faster than even he dreamed possible. A self-described "crazy-ass" plan he and his Australian colleagues concocted to double the world's output of solar power right out of the gate won backing from two of Silicon Valley's most prominent venture capitalists, Ray Lane of Kleiner Perkins Caufield & Byers and Vinod Khosla,

Field of Mirrors

Ausra says its solar thermal plants can provide large amounts of electricity at relatively low cost, without emitting the gases linked to global warming. Here's how:

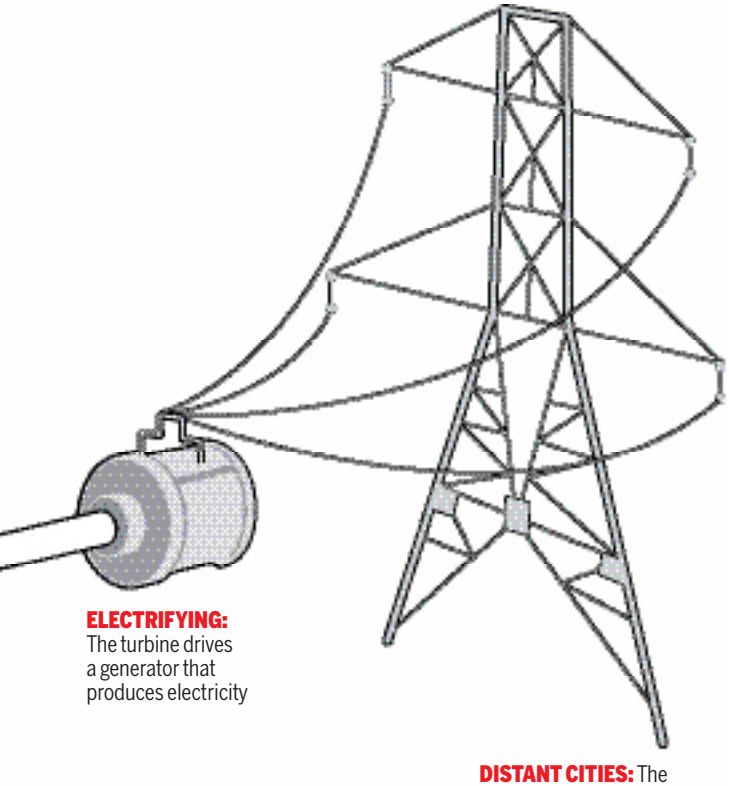


JOE CALVIELLO/BW

co-founder of Sun Microsystems Inc. Lane and Khosla, in turn, have been unusually active selling the approach to governors and utilities.

The company they've invested $47 million in, Ausra Inc., has a pilot operation, dubbed Godzilla for its blast of steam, up and running in Australia. In late September, Ausra, Pacific Gas & Electric, and Florida Power & Light announced commitments for 1,000 megawatts of solar power—as much as a nuclear plant. The details are still in negotiation. But the current plan is to start with a 10-MW demonstration plant in Florida, then expand to 300 MW. With PG&E, Ausra expects to kick off with a 175-MW plant. These facilities could be ready to flip the switch as early as 2010. The main lure: Ausra believes it has solved the biggest problem solar power has faced previously—its high cost. "What I find attractive about Ausra is that it's taking approaches used in the past and driving the price down, making it cheap," says PG&E CEO Peter A. Darbee. "It's lower risk and environmentally friendly. I'm very enthusiastic about the technology."

A "crazy-ass" plan—but backed by top Silicon Valley venture capitalists



ELECTRIFYING: The turbine drives a generator that produces electricity

DISTANT CITIES: The solar power links to a transmission grid that carries power from the desert to cities

By the time these plants are built, O'Donnell hopes to have five times that much capacity under way. "Not only is this the best renewable technology, it is one that could really scale up, both here and in developing countries like India and China," says Khosla.

It strains credulity that a semiconductor executive with no power-plant experience would stumble on an affordable solution to global warming and world energy needs in Australia. "It's an unlikely tale," says venture capitalist Lane. But the spotlight shouldn't be on him, O'Donnell insists. It should be on the Australian scientist David Mills, who toiled for years to develop the technology, and on his competitors.

Indeed, O'Donnell's company is just one of a host of contenders in the race to deliver emission-free energy with solar thermal technology. Spanish clean-energy giants Abengoa Bioenergy and Acciona have jumped in with projects in Spain, Algeria, and the U.S. Israel's Solel Solar Systems has contracted with PG&E to deliver 553 MW from future plants. BrightSource Energy in Oakland, Calif., has reunited some of the pioneers who, in the 1980s, built nine solar plants in the Mojave Desert. "With Ausra, the Spanish companies, and Israel, the solar space has gotten very competitive," says Michael R. Peevey, president of the California Public Utilities Commission.

THE 10¢ SOLUTION

WITH UTILITIES SCRAMBLING TO MEET mandates for green power in 25 states plus the District of Columbia, analysts say there's room for many companies. Ultimately, the technologies that deliver reliable power at the lowest price will win. They'll be a big success if they supply electricity at a price close to a new coal or natural gas plant today. The magic figure is 10¢ per kilowatt-hour (kwh) or less. "If we can lock in a 10¢ number for the life of a solar plant, it will be a clear winner," says Mark Kapner, senior strategy engineer at Austin Energy.

There's an intense debate about which of the competing solar thermal approaches will hit that target—and whether it's imminent or 5 or 10 years away. Ausra's unique claim is that its simpler technology brings it down to the crucial 10¢ already—even with the extra risk premium investors are demanding. "They've engineered out a lot of the costs," explains Lewis Hay III, CEO of Florida Power & Light. Competitors acknowledge they're at least a few years behind in making their approaches as cheap as Ausra claims to have done, even though most experts agree such cost reductions are going to happen. "It seems there is a pathway to very low-cost concentrating solar power," says Andrew Kinross at Navigant Consulting Inc. "This opportunity is finally taking hold."

The opportunity will be even greater when Washington makes it more expensive to emit CO_2, as part of the world's efforts to slow climate change. "Everyone thinks an increase in the cost of carbon is coming," says David Crane, CEO of NRG Energy Inc., a power generator based in Princeton, N.J. That would make the cost of electricity from coal jump 20% or more.

Six-foot-two, with the lean physique of a lifelong cyclist, O'Donnell is an impatient and peripatetic advocate for his energy solution. "He's obviously promoting his own company, but he has also been one of the leading voices for a unified effort to invest in carbon-free power generation," says Tom Plant, director of the Governor's Energy Office in Colorado. "I see him everywhere." O'Donnell can be found in governors'

FLAT PANEL Ausra's mirrors train desert sun on a water pipe

or senators' offices, or telling a staunchly conservative rural Nevada county commissioner not about the threat of global warming but about all the good jobs solar generating plants will provide. Officially Ausra's executive vice-president, "John has been the evangelist," says Lane. O'Donnell took flying lessons so he could pilot his own plane to his company's remote power plant sites. "John and I flew to eastern Nevada in a little Piper," recalls Scot Rutledge, executive director of the Nevada Conservation League. "It was one of the scariest and most exhilarating flights I've ever had."

WIRED ALL THE TIME

I FIRST MET JOHN 35 years ago. We shared a suite during our sophomore year at Yale College. I knew him as brilliant and anguished, with a nerdish prankster side. (When I told VC Lane about the college connection, he said: "How did you stand it? John is wired 100% of the time.") I lost touch with him after that, and we didn't cross paths again until 2001. Since then, I've watched his foray into solar energy. First, with skepticism. ("Yeah, right. You are going to build billions of dollars' worth of power plants and save us from climate change.") Then my interest grew as the vision began to become reality, complete with technology, high-powered celebrity backers, and major utility customers.

For O'Donnell, the journey began in the summer of 2005, when he heard a talk by Nobel laureate Steven Chu, director of Lawrence Berkeley National Laboratory. "Chu said that everything you've heard about climate change is wrong. It is much worse than people know—and every engineer should be working on it," O'Donnell recalls. He got his chance the following April when he left Equator, the video-processing chip company he had founded, with about a year's salary.

> The usual green darlings, photovoltaic cells and wind, fall short compared with solar reflectors

He traveled to conferences, read scientific papers, talked to researchers, and became convinced Chu was right. Yet averting the now familiar perils of global warming—floods, fierce storms, and famine—requires almost unimaginable changes. It means slashing emissions of CO_2 by a mind-boggling number—up to 80% within 40 years, according to the latest report from the Intergovernmental Panel on Climate Change (IPCC).

O'Donnell quickly rejected nearly all the proposed replacements. The use of so-called clean coal requires capturing and storing carbon, which is too costly and impractical, he concluded. The usual green darlings, wind turbines and panels of solar cells, fall short. When the afternoon sun scorches and people crank up their air conditioners, the breezes typically die. "Wind can't be relied on over the peak hours," says Fong Wan, vice-president for energy procurement at PG&E. Therefore, it can supply only 15% to 20% of electricity needs.

Neither can solar photovoltaic panels make much of a dent because they're too expensive. "Solar PV is a nice business, but it has nothing to do with climate," says O'Donnell.

He doesn't hide his disdain for many in the green camp. "A lot of people in the environmental community act as if they can't count," he complains. "If we are really serious about this, we have to have something that's large enough at a cost that makes sense, and which can power the U.S. and Europe—and also go to China and India."

By the spring of last year, O'Donnell concluded that the

MIRROR TROUGHS
Acciona's reflectors heat oil in Nevada

only feasible approach was concentrated solar thermal technology, covering the ground with acres of mirrors to make steam to drive turbines. This is the technology an Israeli company, Luz Corp., used to build the nine power stations in the Mojave Desert in the 1980s. Those power plants employ parabola-shaped mirrored troughs to beam sunlight on an oil-filled tube in each trough. The oil then heats water to make steam. Those plants are still working, generating 354 MW of electricity with superb reliability, but costs never fell to a level that would impress utilities.

Meanwhile, Spain's Acciona was building an updated 64-MW version in the Nevada desert. The parabolic troughs work well. But the mirrors, among other things, have to be very precise, making them difficult and expensive to build. The original series of plants in the Mojave managed to bring the cost down from 28¢ per kwh to 16¢, while the newer ones are a penny or two cheaper. But O'Donnell was determined to start at 10¢ and go down from there.

So was there something better and less costly?

How Solar Is Warming Up

Using different shapes of mirrors to focus the sun's heat onto pipes or towers, companies are competing to build new power plants. Below are their projects and plans (1,000 megawatts can power 750,000 homes):

1980s	354 MW of trough-shaped mirrors in the Mojave Desert (Luz)
2004	1-MW plant with flat mirrors in Australia (Ausra)
2006	1-MW trough plant in Arizona (Spain's Acciona Energia)
2007	11 MW with mirrors shining on a tower in Spain (Abengoa) 64-MW trough plant in Nevada (Acciona)
2008-2009	Three 50-MW troughs in Spain (Solar Millennium; Abengoa) 25-MW trough plants in Algeria and Morocco (Abengoa) 20-MW tower project in Spain (Abengoa)
2010+	500+ MW dish-shaped mirrors (Stirling Energy Systems) 553-MW trough plants in California (Solel Solar Systems) 700-MW flat-mirror plants for PG&E and FP&L (Ausra)

Data: Morse Associates

'IT WORKED'

O'DONNELL STUMBLED on the answer thumbing through a scientific journal at an engineering society meeting in May, 2006. A paper by University of Sydney professor David Mills described a field of almost flat mirrors focusing the sun's rays on fixed tubes held by poles above the mirrors (diagram). Such mirrors are easier and cheaper to build than the parabolic troughs, and can be made strong enough to withstand Florida's hurricanes. And rather than using the troughs' oil-filled tubes, which sap power to pump the oil, Mills uses the sun's heat to turn water directly into steam. "It just riveted me. I thought: 'Whoa, Mills is either a genius or a madman,'" O'Donnell recalls. "If it can compete with coal even at the beginning of the learning curve, it will change the world."

The more he learned, the more intrigued he became. Mills had been working on solar technologies for three decades. In 2002 he had hooked up with local businessman Peter Le Lièvre, who had been building vehicles with liftgates that ranchers use to hoist and transport sheep.

In a rented garage, Le Lièvre bolted together the parts for the first mirror. His team barely got it out between the garage's pillars. But it worked. "That first mirror had great focus," says Le Lièvre. "It would burn the hairs off the back of your hand." On a shoestring, they assembled 60 mirrors into a 1-MW array next to a coal plant in Liddell, New South Wales. When they flipped the switch, steam gushed out. "Everyone was aghast that it worked the first time," says Mills.

O'Donnell sent Mills an e-mail in May, 2006. "I told John more or less to get lost," Mills says. "But he was quite persistent." In September, O'Donnell flew to Australia, where he met with more skepticism. "We said, you would have to offer us a ridiculous amount of money because we were on a very good wicket," says Le Lièvre.

O'Donnell didn't have deep pockets, but he had good contacts. He had been helping Vinod Khosla evaluate solar companies. The Australian approach, he told Khosla, was the

best. He and Le Lièvre hastily wrote a plan to build 2 gigawatts (2,000 MW) of power plants, doubling the world output of solar power "as our opening act," O'Donnell says. In early October, Mills and Le Lièvre visited California. "I didn't know who Vinod Khosla was, so I was completely fearless," recalls Le Lièvre. Six days later, O'Donnell, the Australians, and the VCs settled on the terms of the eventual $47 million investment.

Khosla still had questions. "We knew it would work, but at what cost and what level of performance?" Khosla says. "Would the glass delaminate after 15 years, or the coating on the tubes deteriorate?" Khosla paid the engineering firm Black & Veatch Corp. to study the array in Australia. "It's very atypical for venture capital to spend that much on diligence," Khosla says. PG&E also sent engineers. The results were good.

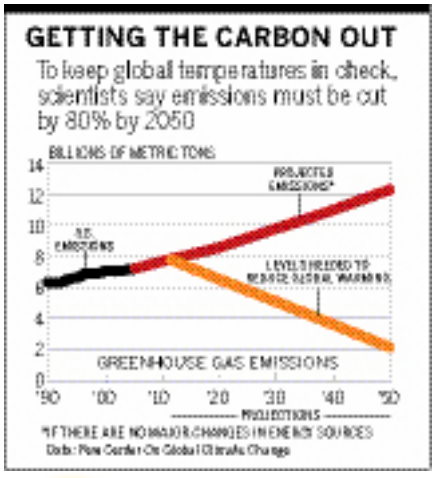
The new company, Ausra, found space in Palo Alto, Calif. Mills and Le Lièvre uprooted their lives and moved nearby. (Le Lièvre rides to work on a bike propelled by a rowing motion—a full-body workout recommended by his Pilates instructor wife.) O'Donnell hired two utility executives with experience building power plants in Chile, India, and El Salvador.

O'Donnell bubbles with enthusiasm about the group he has assembled as he and I pedal around Palo Alto on his recumbent tandem bicycle. "It's the greatest privilege of my life to come to work," he says. "We have the vision, the connection to larger problems, the fundamental science, the commercial team, and the finance team."

It's a giant leap, though, going from a promising technology to building a $400 million 100-MW plant. The first important step is contracting with a utility to deliver electricity at a set price—a so-called power-purchase agreement—which Ausra hopes to announce soon with PG&E and FP&L. But it's tricky. If the solar plant bids too low and can't deliver at the price, its investors would take a bath.

As a result, investment bankers are cautious. Acciona faced a number of hurdles building its 64-MW solar plant in Nevada but was ultimately able to get financing because the basic parabolic-trough technology had already been proven. "The issue of risk is a very real one. If similar plants had not been operating for 20 years, they would have had a much tougher time," explains longtime industry consultant Frederick H. Morse, now senior adviser to Abengoa.

As a startup with newer technology, Ausra faces harder financial challenges. Coal plant builders have been able to count on 80% to 90% debt at an interest rate of 5.5% to 6%. Their equity investors expect about an 11% return on equity. That puts the average cost of capital at about 7%. But since no one has built a giant solar plant, investors demand a risk premium. O'Donnell's equity investors want a richer 20% rate of return. Plus, he can get only 50% debt, at an interest rate of 7.5%. As a result, the overall cost of capital for Ausra's first plants is 12%.



The first few big solar plants need to show investors that the risk is low

The hope, therefore, is that the first few large plants show investors that the risk is low, causing the future cost of capital to drop. That would enable Ausra to lower the price below the current 10.4¢. "Once people build one or two units, the financial risk premium goes away," explains Jim Ferland, senior vice-president at New Mexico utility PNM.

The uncertainty hasn't stopped investors. There's a sense in the financial community that booms in wind and ethanol are over. The next thing? It looks like solar. "There has been a dramatic increase in deal volume on solar projects," says Keith Martin, partner at Chadbourne & Parke in Washington. "It is our fastest growing area of financing here."

This trend helps Ausra. In mid-September, the company hired a veteran utility executive from Calpine Corp., Robert E. Fishman, to be CEO, freeing O'Donnell to be the full-time evangelist. Ausra is also busy working on deals in Arizona, Colorado, and Nevada. "They clearly believe there are technology solutions to our energy challenges, and they are developing them while most in Washington are sitting around arguing," says Senator Jeff Bingaman (D-N.M.), chairman of the Energy & Natural Resources Committee, who has met with O'Donnell and Khosla.

Ausra's Big Solar competitors say the company is out on a limb. When Ausra builds its first plant, skeptics predict, it will encounter engineering challenges that will raise the price. "They are proposing prices that are very low," says Morse. "But if they're right, if it is financeable and if it works reliably for 30 years and meets utilities' needs, it will be a great success. The utilities that go with them will look like geniuses, and so will you for writing about them."

Basic physics shows enough sunlight falls on the deserts of the Southwest to provide all of American's electricity many times over—given enough mirrors. But O'Donnell is already thinking about the next step—going global. He figures Europe could get all of its electricity from Big Solar plants in Morocco. He even has a sneaky China plan. "Frankly, the original goal for the company was to get an arms race started, where we move ahead in the U.S. and then China decides to get in on the act," he says. "If they copy us, that's fine! Fine!"

That kind of comment has his colleagues rolling their eyes. "John sounds a bit like a crazy scientist," says Lane. "His brain is so sharp and his IQ is so high, he just doesn't know what is coming out of his mouth. But all the stuff he was talking about a year ago, we now are all saying. We need him to keep pushing it forward." zz

–With Adam Aston

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BRIGHTER DAY: To see how solar panels can cut your home electricity bills, watch a video report at **businessweek.com/go/tv/solar.**

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