Looking up: Bill Gross, serial entrepreneur and CEO of Energy Innovations.

THE DOTCOM KING & THE ROOFTOP SOLAR REVOLUTION

Idealab impresario Bill Gross couldn't wait for the dawn of the sun age. So he built a high-energy, low-cost solar concentrator that will fit on your roof. And overthrow the powers that be.

BY SPENCER REISS

PHOTOGRAPHS BY JOE PUGLIESE

SHORTLY AFTER DAWN

on a typical Arizona morning, a wave of photons born eight minutes earlier in the big yellow fusion reactor in the sky clears the Superstition Mountains and sweeps across Phoenix and the Valley of the Sun. On a fenced-in stretch of gravel at the edge of booming Mesa – the largest suburb in the US – the stream of newly minted light strikes what looks like a lunar lander, all bundled wires and glinting aluminum. The photons ricochet off 25 mirrors arranged in a 5- by 5-foot square and converge in a shaft of light brighter than the sun at high noon. The tightly focused stream crashes into 100 square inches of silicon suspended over mirrors, sending a spray of electrons dancing down a copper wire. A CPU revs and tiny motors whir. As one, the mirrors adjust their positions ever so slightly. And the latest attempt at keeping pace with humanity's epic appetite for energy begins another day of pulling power from the sky.

This package of precision engineering is called the Sunflower, which is what one of its early prototypes vaguely resembled, four years and 40-odd iterations ago. The yard it sits in belongs to Arizona State University's Photovoltaic Testing Lab, where devices that turn sunlight into electricity go to prove their stuff. Over the next three months, a half-dozen Sunflowers will be toasted, roasted, scorched, and drowned. They'll endure showers of fake hailstones fired from air guns, snowdrifts simulated with water-saturated foam-rubber blankets, and 25 years' worth of punishing ultraviolet radiation. If all goes well, the spoilsports at Underwriters Laboratories will crack what passes among them for a smile. A crew of solar-energy fanatics operating out of a converted Korean restaurant in Old Town Pasadena, California, will cheer. And Bill Gross will, well, beam.

Bill Gross? The name will be familiar to veteran dot-bomb watchers – Mr. Idealab!, the Caltech geek turned manic entrepreneur who fostered NetZero, FreePC, and CitySearch. And eToys, Eve.com, and FirstLook. Not to mention MyBiz.com, Paythrough.com, Refer.com, and Sameday.com. And don't forget Utility.com, WeddingChannel.com, Zelerate, and PETsMART. The prototypical startup incubator, Idealab! launched more than one company a month during the three headiest years of the late, great dotcom gold rush.

With the Internet now slouching into adolescence, many of its early highfliers have moved on. Mark Cuban is cheerleading the Dallas Mavericks, hawking HDTV, and digitizing movie theaters. Elon Musk is building spaceships. Jay Walker is hustling "business DNA." Others are racing sailboats, polishing Ferraris, toasting marshmallows over defunct stock-option certificates, or crying in their Gordon Biersch.

But Gross is still at it, a 46-year-old Energizer Bunny blinking behind wire-rimmed specs. Idealab – now minus the exclamation point – sprawls across 50,000 square feet of Lucite and red brick in Pasadena. At the moment it's home to a clutch of startups doing everything from P2P phones to cable-free optical networking. There's X1 (Yahoo! has licensed its desktop search software) and Evolution Robotics (Sony used its technology in the Aibo). In mid-2003, Yahoo! paid $1.6 billion for Overture, Gross' pioneering Web advertising business. Last year, Google plunked down an undisclosed sum for Picasa, his online photo service.

But forget all that. On a rainy Southern California morning, the venture that has Gross struggling to stay put in his Herman Miller chair is the one that planted the Sunflower in the Arizona desert. It's as much a personal cause as a business; for the first time in Idealab's tumultuous nine-year history, the Incubator himself has stepped in as CEO. He has taken a plywood-door desk right out in the bullpen with a cheerful crew of heat-transfer engineers, Jet Propulsion Lab veterans, CAD-CAM programmers, even a vending machine specialist hired for his expertise at building things reliable and maintenance-free. An 8-foot mirror-petalled prototype hangs from the high ceiling. A banner suspended overhead blares the company name: ENERGY INNOVATIONS.

Gross talks the way the sun spews photons. During a 7 am breakfast in an empty local eatery that seems to be open early mainly for him, Radio Free Bill is broadcasting on all channels. The infomercial is pure energy – the kilowatt kind – and the pitch includes something for everyone.

For conspicuous consumers: "America's secret," he says, "is that each of us uses an average of 17 virtual horses' worth of electric power every day." He means that approvingly; no turn-the-lights-off Luddite, he.

For the no-blood-for-oil crowd: "The rest of the world needs cheap, reliable power too, if we're going to end the wars over energy and bring on a new age of global peace and toleration."

For investors: "Reinventing energy is a multitrillion-dollar opportunity. It's the next big disruption. It dwarfs any business opportunity in history."

For Energy Innovations' crew of 35 solar geeks: "We've been looking for a big problem to get our hands around, and we think we've got an answer." That's for Gross himself, as well. What's left to do after you've ridden the Net rocket from liftoff to splashdown? Why, you save the world.

IN THE DARK, pre-PC middle decades of the past century, before nerdy kids started building motherboards, programming Linux tools, and dabbling in viruses, two surefire signs distinguished a budding geek. One was a ham radio fixation (Apple cofounder Steve Wozniak's call sign is WA6BND, celebrity hacker Kevin Mitnick's is N6NHG). The other was a fascination with solar power.

Contributing editor Spencer Reiss (spencer@upperroad.com) *profiled Richard Branson in issue 13.01.*

HE ESCAPED THE BUST INTACT. NOW HE NEEDED A CHALLENGE – SAY, THE GLOBAL ENERGY CRISIS.

The Sunflower 250: the first solar concentrator small and light enough to fit on a roof.

Bill Gross caught the sun bug as an undersize math and science whiz in Van Nuys, California. He entered high school during the oil shocks of the 1970s, which paralyzed the nation with high gas prices and long lines at pumps. Like a real-world Tom Swift Jr. – the heroic boy inventor in 1950s pulp fiction – Gross spent his Saturdays riding the bus to LA's Central Library, where he read everything he could find about the mysteries (and realities) of solar energy. "There had to be a way to fight back," he says, "to use math and science to allow man to harness the sun."

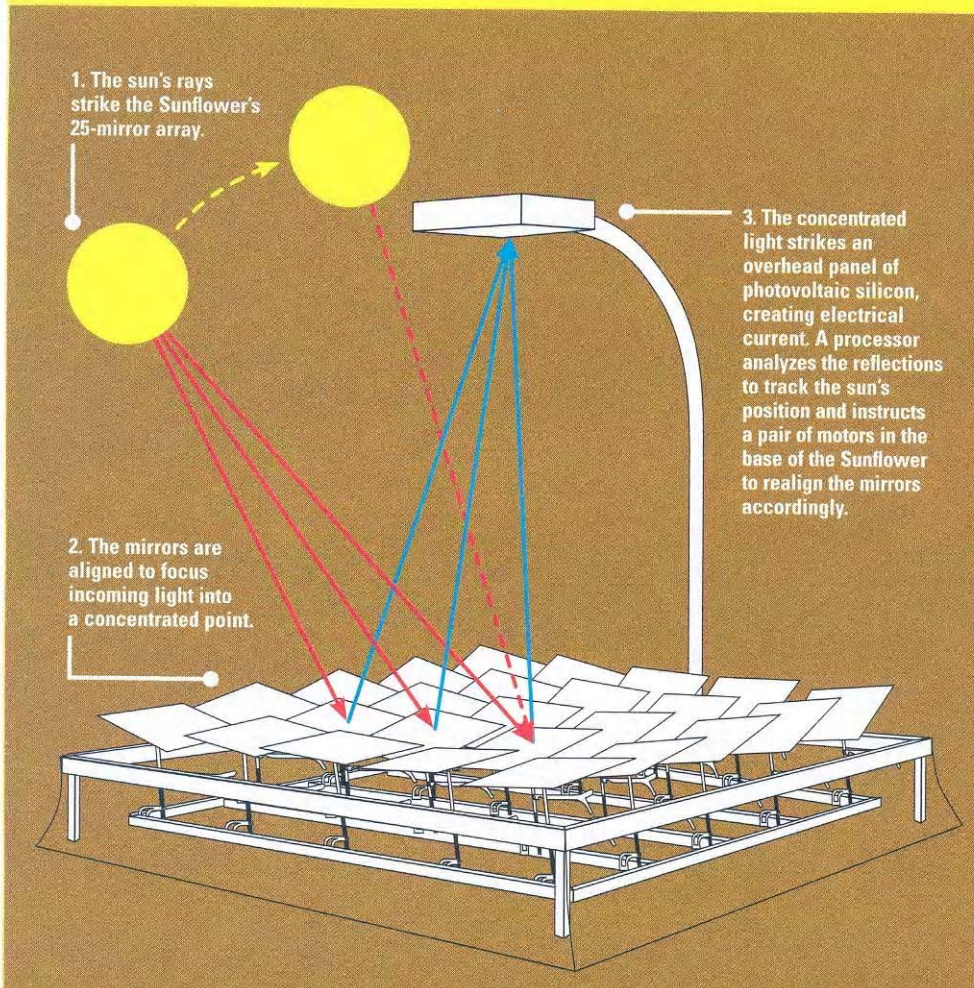
He didn't vanquish OPEC, but he did start a nice little business. Placing a tiny classified ad in the back of *Popular Science* – "Build Your Own Solar Dish: $4" – Gross sold hand-drawn diagrams and kits for making sun-powered water heaters and ovens capable of roasting hot dogs. The money was good enough to pay for his first two years at Caltech, where he stealthily changed his return address – a dorm called Ruddock House – to read "Ruddock Labs." From there, he jumped to building and selling hi-fi speakers, then hopscotched into marketing newfangled PCs. Though he took his BS in mechanical engineering in 1981, he could see which way the wind was blowing and dove into a lucrative string of software startups, capped by the CD-ROM pioneer Knowledge Adventure. By the time he launched Idealab! into the Internet gale in 1996, solar ovens – indeed, anything involving messy, low-margin atoms – were as passé as 8-track tapes.

Fast-forward to the new millennium and the dotcom flameout. Although Idealab survived, many of its bubblier projects evaporated. "We saw how people beat you up for failure," Gross says. "One of the lessons was to do things we care passionately about, things we'll go to the ends of the earth to make succeed." Soon after, California lurched into its own energy debacle, the blackouts of 2001. Prices spiked, lights flickered. Calling Tom Swift!

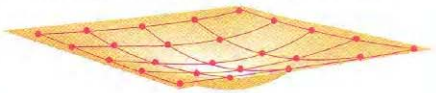
Alternative energy had never gone entirely out of fashion. While rabbits like Gross romped in the Net's green pastures, the tortoises of solar energy's parched commercial desert continued to poke along. Half a century after Bell Labs engineers demonstrated the first silicon-based photovoltaic cell, the cost of solar electric power was falling by 50 percent every decade – not the pace of Moore's law, but respectable. By the early 2000s, sun-powered call boxes dotted highways, and remote ranches sprouted solar pumps. Solar oases blossomed in unlikely places like Japan and Germany. A former Texas oilman put solar panels atop one of the outbuildings at his temporary residence at 1600 Pennsylvania Avenue.

There's just one problem: Covering large expanses of real estate with painstakingly processed silicon is expensive. Without what the

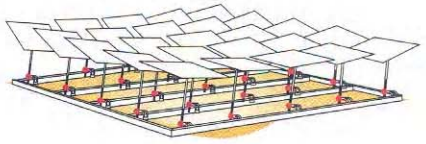
HOW THE SUNFLOWER SOLAR CONCENTRATOR WORKS

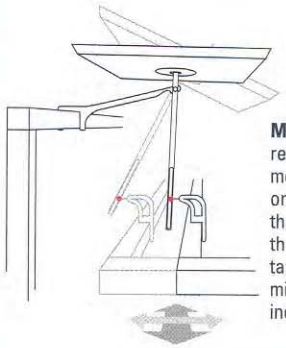


The challenge for Energy Innovations' engineers was to keep a grid of 25 mirrors focused on a single point as the sun travels across the sky – and to do it cheaply. The goal: control each mirror independently without requiring separate motors for each mirror.



The key: a surface – based on a mathematical curve called the conchoid of Nicomedes – that dictates the position of each mirror. The surface, sampled at 25 points, is represented in the Sunflower by a grid of ball bearings attached to a swinging frame.





Moving the frame requires only two motors: As it swings on an x-y axis, the bearings move the mirrors in tandem, yet each mirror follows its individual path.

SUDDENLY HIS GRID OF MOVING MIRRORS DIDN'T NEED 50 MOTORS – IT ONLY NEEDED 2.

industry coyly calls "incentives" – government subsidies, rebates, tax credits, and the like – photovoltaic panels wouldn't have much of a market. Even in sunny places like California, the pre-rebate cost of PV-generated electricity is roughly 21 cents per kilowatt-hour. Coal (from 4.74 cents per kilowatt-hour), natural gas (5.15 cents), nukes (5.92 cents), even windmills (5.15 cents) offer cheaper ways to keep the lights on.

But PV's price differential isn't quite as bad as it seems, thanks to one huge advantage: Solar panels are small enough to fit on rooftops, which is darn close to the electricity user. By bringing energy production and consumption together – something coal, nukes, and gas can't do – solar has the potential to cut out the middleman, along with his markup. That is, instead of competing with wholesale power from distant power plants, rooftop solar competes with *retail* kilowatt-hours delivered by the local electric company, which often are marked up as much as 1,000 percent over their original generating cost. What's more, retail prices typically peak on hot, sunny summer days, when air conditioners suck every last electron from the grid – precisely when solar panels are most productive. Add a final boost from government handouts, and solar can get over the hump, especially with homeowners and other customers whose motives might not be purely economic.

Hence the mainstream solar industry's strategy: Be patient. Keep priming the pump with government money. Eventually – say, 20 years from now – mass production and technological improvements will make solar power fully competitive with coal, gas, and nuclear. And then the market will explode.

Which brings us back to Gross, who has all the patience of a guy who seized upon the Internet incubator model because it let him launch company after company while letting others do the dreary follow-up. He had made it out of the dotcom bust with his company intact, enough money to bankroll select projects, and a renewed taste for ideas that involved more than just evanescent bits. What he needed was a challenge worth his while – say, California's power crisis and its hint of a looming global energy meltdown.

The 15-year-old in him immediately saw the answer: solar power!

The Caltech mechanical engineer took only a little longer: If solar's problem was the high cost of PV silicon, the solution was to *use less of it*. Or maybe none at all.

And the serial entrepreneur? He found his opportunity while looking out the window of a Southwest Airlines 737 shuttling from Silicon Valley to Burbank. "I saw this huge expanse of flat, commercial rooftops," he recalls, "and I realized that that could be a great market. I could just see all those buildings covered with row after row of solar collectors." Ka-ching! Solar sprawl!

THERE REALLY IS nothing new under the sun. According to legend, Archimedes set aflame a fleet of besieging Roman warships using "burning glass" – presumably mirrors – to focus the sun's power. The principle has not been lost on solar engineers. Even as PV researchers struggled to make their technology commercially viable, sunbelt utility companies were experimenting with solar concentrators.

PG&E's 350-megawatt Solar Electric Generating Station, for instance, sits in the Mojave Desert a couple of hours' drive from Pasadena. Built in the 1980s, the installation uses parabolic dishes, mirrored troughs, and "power towers" surrounded by fields of reflectors, aided by complex mechanical gear that tracks the sun's path across the sky.

Such behemoths still can't generate electricity as cheaply as a coal or nuke plant, but the effort to bring down the cost has driven engineers to bring up the size. The latest solar megadish from Sandia National Laboratory and Stirling Energy Systems delivers impressive 30-percent efficiency, half again better than the best commercial PV. It's also four stories tall and weighs 8 tons. Forget about mounting it on anyone's roof.

Gross turned that bigger-is-better thinking upside down. By combining Internet-age technology, clever design, and inexpensive Chinese manufacturing, he realized that a radically downsized solar concentrator could retain all the efficiencies of its giant cousins and also fit on a roof. It was the PC paradigm all over again.

Gross' R&D team tried at first to avoid silicon entirely, converting concentrated sunlight into electrons with a Stirling heat engine, a superefficient refinement of the steam engine. When that proved too difficult to bring to market, the engineers set it aside and reluctantly turned back to silicon. They tried dozens of configurations to maximize the stream of photons: 8-foot parabolic dishes, arrays of 500 tiny motorized mirrors, ridged Fresnel lenses mounted in gleaming aluminum tubes. By the start of 2004, there were two contending designs: a clamshell-style reflective dish that closed up in high winds and a grid of moving mirrors.

Then, in a weekend flash of inspiration, a young Caltech physics grad named Kevin Hickerson figured out how to reduce the number of motors needed to move 25 mirrors independently, a major cost factor. Instead of two motors for each mirror – the traditional approach – Hickerson's solution requires only two motors for any number of mirrors. The key is a mathematical curve known as the conchoid of Nicomedes (named for the ancient Greek mathematician, who discovered it). A grid of ball bearings arrayed to match the conchoid is attached to a frame inside the Sunflower. As the motors move the frame, the bearings control each mirror's position individually.

The resulting Sunflower 250 is heavy enough to stay put in high winds, but light enough to be lifted by two installers. To take full advantage of outsourced manufacturing, it's sized to fit into a shipping container; commercial units could be transported to your favorite big-box retailer's rooftop direct from the Shenzhen factory.

The Sunflower's solar receiver, suspended above the mirror field, contains a $2 chip that provides the brains, including an IP 151➡

←141 address for remotely monitoring power output and possible malfunctions. The overhead assembly also holds four high-efficiency PV wafers that convert more than 20 percent of incoming light into electricity – half again more than standard panels – for a peak output of 1 kilowatt-hour per sunny Los Angeles day. This special silicon comes from a Northern California company called SunPower, purchased three years ago by chipmaker Cypress Semiconductor. Cypress celebrity CEO T. J. Rodgers poured $10 million into SunPower and is now planning to spin out the company in an IPO later this year.

How big a challenge Gross' solar concentrator will be to conventional PV panels should start to become clear when his first 1,000 beta units begin rolling off the assembly line this fall. Energy Innovations' figures show that the Sunflower has a 30 percent cost advantage over typical PV panels before rebates and, in most locations, an even bigger advantage after. Consider a hypothetical Los Angeles light-manufacturing business with 35,000 square feet of roof space. A $684,000 investment (after rebates) in PV panels would generate 90 percent of the company's annual power needs and save roughly $52,000 a year on its electric bill. An array of 750 Sunflowers would deliver the same benefits for $228,000.

Gross hopes to push the price down another 20 percent within two years as manufacturing scale and more efficient silicon kick in. His focus is the metric nearest the hearts of penny-counting CFOs and facilities managers who rule all those endless miles of sprawling rooftops: payback period. "Right now, PV solar has a 20-year payback, but people are still buying it," he says. "Our target for California is five. In Phoenix we could do 3.3."

Of course, those alluring numbers hide a little secret: Take away rebates and other incentives, and payback periods pretty much double. The hard reality is that, even on the rooftop, even with concentrated sunlight, even with low-cost Chinese manufacturing, unrebated solar kilowatt-hours cost too much for the mainstream energy market. Gross is bold enough to think the Sunflower has a shot at competing straight up with the utility companies, and certainly sooner than the 20-year forecast for PV panels. But for now, he'd rather not have to find out. "Losing rebates would be devastating to all of us," he says. "This is still a very young industry."

The toughest question hanging over the Sunflower is whether its electronics and sophisticated machinery can survive a 15-year design life blasted by wind, dust, and – yes – sun. (Not to mention its own concentrated solar heat: One prototype accidentally focused its beam on a photographer's tripod, which burst into flames.) Underwriters Laboratories testing will go some way toward assuaging such concerns. The first set of customers will get something even more reassuring (and, potentially, expensive): a 15-year full-replacement guarantee.

But there's no doubt about the potential market. A recent report by the consulting company Navigant tallies more than 2 *billion* square feet of flat commercial roof space in California alone – a figure predicted to hit 3.6 billion by 2010. Some buildings offer as much as 800,000 square feet, big enough for 20,000 Sunflowers, or half a megawatt of peak generating capacity. Says Energy Innovations president Andrew Beebe, who's heading the sales team, "There are potential customers out there who could fulfill our business plan for the first two years." Pie in the sky!

Don't break out the dessert forks just yet. From nuclear reactors to windmills, new energy technologies are notoriously difficult to shepherd from brilliant concept to world-beating product. Solar, the most elegant in theory, could well be the toughest of all. Indeed, from Arizona to Australia's outback, the sun-scorched landscape is littered with formerly high-flying startups: Luz, AstroPower, TecStar's Applied Solar division. "Bleached bones," one industry veteran calls them.

When it comes to Bill Gross and Energy Innovations, the most obvious worry is the strategy of combining multiple high-risk elements: solar concentration, high-efficiency silicon, offshore manufacturing. "I wish them all the luck in the world," says Mike Rogol, an equity analyst for Credit Lyonnais who recently surveyed more than 100 solar-industry companies. "But the more things you try to innovate, the more chances there are for something to fail. That's why the PV guys have learned to keep it simple."

Gross proffers a tart reply. "Our Unit 1 beats what they've done with PV panels after 50 years of work and $20 billion in investment," he says, fiddling with an alpha-version Sunflower in his machine shop. "We've spent $12 million so far. I'd say we're off to a pretty good start."

There's also the common notion – especially on Wall Street – that solar energy is the commercial equivalent of a trust-fund kid, never quite able to stand on its own feet. "Politics, not business," an eminent Silicon Valley VC sniffs.

"We're changing that," Gross shoots back. "We're the first people to come along with enough capital, engineering ingenuity, and smarts to say 'It's the *economics*, stupid.'"

THE BEAM ACCIDENTALLY FOCUSED ON A PHOTO TRIPOD, WHICH BURST INTO FLAMES.

Gross can count on a powerful ally. One that never sends a fuel bill and self-stores waste. That's 93 million miles from anyone's backyard, and now in its sixth billennium of trouble-free operation. That sends enough photons winging to Earth every hour to meet mankind's power needs for a year. Snatch just a fraction, the dream goes, and LNG supertankers will join whale oil in the Smithsonian museum. Nukes can go back to being bombs. Peace will guide the planet. And you can tell Reddy Kilowatt to go to hell.

By email late one night, Gross replies to a question about solar energy's long slog toward a place in the sun. "A small group of fanatics will go solar when it's not cost-effective. The WHOLE WORLD will when it is!" That is, in fact, the way the world tends to work. Remember how you once needed a Sun Sparcstation to log on to the researcher's playpen called the Internet? And how, with the advent of cheap PCs, the Net erupted in a glorious World Wide Web? Bill Gross certainly does. ■ ■ ■