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STAN OVSHINSKY'S SOLAR REVOLUTION

by Lawrence M. Fisher

Photographs by Greg Ruffing

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"The Institute for Amorphous Studies," reads the simple black-on-white sign at a former elementary school in the leafy Detroit suburb of Bloomfield Hills. The sign represents a bit of nerdish humor: The scientists and engineers working here know that it might prompt a visitor to imagine a new-age Silicon Valley–style think tank. But this is southeastern Michigan, and the sign is also serious, reflecting Stanford R. Ovshinsky's discovery half a century ago of amorphous materials, the science at the core of such diverse products as nonvolatile memory chips, flat-panel displays, and rewriteable optical discs.

That discovery created an entirely new field of materials science, and Ovshinsky's achievements have continued over the subsequent decades. Although his formal education ended with high school, he has written some 300 scientific papers; has more than 400 patents to his name for technologies that have improved daily life in myriad ways; and has been awarded dozens of honorary degrees, awards, and academic accolades. Now, at age 88, he has formed Ovshinsky Solar, a company with an audacious goal: to drive the unsubsidized cost of solar power below that of coal — to create, in effect, a Moore's Law for energy.

The automatic response to a man late in his ninth decade announcing such an objective is disbelief, perhaps tinged with amusement. Certainly the doors of venture capital firms do not open readily to octogenarians, no matter how accomplished. But Ovshinsky has spent his entire career ignoring the naysayers, and time after time he has proved them wrong the best way he knows: by overturning conventional scientific wisdom, creating breakthrough technologies, and building things that work. In this new endeavor, feeling he has no time to waste, he has assembled a small team of scientific and engineering talent to make low-cost solar power a reality as rapidly as possible.

The *Economist* once called him "the Edison of our age," and he has also been compared to Einstein. But Ovshinsky sees himself less as an inventor or a theorist than as a pragmatic problem solver. He views complex problems not as existential dilemmas or subjects for detached study, but as fundamentally comprehensible tasks lacking only an obvious solution. So global warming and foreign oil dependence are not cause for dissertations or despair, but simply tough equations to solve for multiple unknowns.

It was perhaps coincidental that amorphous materials science, Ovshinsky's pivotal discovery, was equally suited to energy technologies, such as the nickel–metal hydride batteries in the Toyota Prius, and to computer applications, such as memory chips that retain their data after the electricity is turned off, both of which are his inventions. But that duality inevitably shaped his career and his world view.

"I picked energy and information as the twin pillars of our economy very early on, when I was quite young," Ovshinsky says, touching on past times as a prelude to a proximate future. "If you change the energy equation to no use of coal and no climate change, you're ending one era and opening an entirely different one. I'm an activist, but what I do is go out and do it, if I know how."

Ovshinsky keeps his office in the former school's library, and sits at a wooden desk surrounded by scientific texts and the scholarly journals he still reads and contributes to avidly. Pride of place here, and in nearly every room at the company, is given to a large chart of the periodic table of elements, which colleagues say

Ovshinsky knows the way a master pianist knows the musical scales. Time after time, when those colleagues have reached an impasse, he will point to the table and remind them that the answers to their questions are all there.

He points to it today to explain why all his work, including his current focus on low-cost solar power, ultimately comes back to the primacy of the hydrogen atom. "We have a universe, and the first thing out of the Big Bang, which created it, was hydrogen, some helium, and a little bit of lithium. The hydrogen atom is what the whole periodic table is made out of. All matter that we know is, by far, hydrogen: a gas out in the universe that condenses into stars, and gives out energy by fusing hydrogen into helium. That creates the photon light particles that are absorbed onto photovoltaics to generate electricity."

Decades before *green* became a modifier for *technology,* Ovshinsky and his second wife, Iris, opened the doors of Energy Conversion Laboratory in a small Detroit storefront. This was his third company in less than 10 years, but it would be his primary focus for the next half century. It was 1960, yet already the Ovshinskys dreamed of a world free of the wars and pollution caused by dependence on carbon-based fuels and petrochemical products. Iris had the academic training that Stan lacked, including a Ph.D. in biochemistry from Boston University. Working as a team, they created breakthroughs in energy generation, energy storage, information systems, and atomically engineered synthetic materials, now known as nanotechnology.

Indeed, when the clean-energy economy comes to pass, it will owe much to the holistic, practical, and dogged way Ovshinsky and his colleagues have pursued it over the decades. In Ovshinsky's view, inexpensive solar power will make energy both plentiful and clean, eliminating the scarcity-driven conflicts and carbon-based pollution that have dogged humankind for centuries. Furthermore, he is confident that this transition, once begun, will occur rapidly, with the same relentless acceleration that has driven computers from mainframes to iPads in a scant four decades.

Ovshinsky has a touch of vanity — he clearly delights in the svelte figure he still cuts in a well-tailored suit, and he takes a similar pleasure in countering skeptics by displaying patents, peer-reviewed publications, and functioning prototypes that prove his concepts work. The wispy-haired gentleman with the modest manner awaits your interrogation with a kind smile, knowing that you may have tough questions, but that he has the answers and the data to back them up.

Birth of a New Science

Ovshinsky grew up in Akron, Ohio, the elder son of working-class Jewish immigrants who fled eastern Europe in 1905. His father, Benjamin Ovshinsky, made his living collecting metal scrap, but he was also a liberal social activist who introduced his son to the Akron Workmen's Circle, an organization focused on labor rights, civil rights, and civil liberties. In later years, Stan Ovshinsky marched in civil rights protests and hosted activists in his home.

His first jobs were in machine shops around Akron, and his first inventions and first company, Stanford Roberts, were devoted to machine tools. The Benjamin Center Drive, an automated lathe he named for his father, was used to manufacture artillery shells for the Korean War effort. Accepting an offer from the Hupp Motorcar Company, he moved to Detroit in 1951, where he invented a technology for electric power steering. But Hupp's president blocked negotiations with General Motors to complete the project, and it was shelved as the industry moved toward hydraulic power steering.

But Ovshinsky was already moving on, pursuing his fascination with human and machine intelligence. He read deeply in the research literature of neurophysiology, neurological disease, and cybernetics. Despite his lack of formal education, he came to comprehend and make strides in these seemingly disparate and arcane disciplines with the same intuitive and iconoclastic bent he brought to precision machine tools. His own publications in peer-reviewed journals confirmed his insight and innovation in these fields.

With his younger brother, Herb, a mechanical engineer, he established a small company called General Automation to research and develop energy and information technologies. Together they built, in 1959, a mechanical model of a nerve cell, a semiconductor switch they called the Ovitron, in the process pioneering the use of nanostructures. A year later, Stan and Iris opened the Energy Conversion Laboratory.

The Ovitron itself had no practical application, but in developing it, Ovshinsky made a breakthrough that would define his career, and make the "Ovshinsky effect" a science textbook phrase. He discovered that certain types of glassy thin films, known as amorphous or disordered materials, turn into semiconductors upon

application of a low voltage. Semiconductors, the foundation of modern electronics, are materials that conduct an electrical charge but can be regulated, unlike common conductors such as copper.

At the time, in the early 1960s, scientists believed that semiconductors could be formed only from crystalline materials, such as purified silicon, in which all the atoms are arranged in a long-range order. Ovshinsky demonstrated that it was possible to form semiconductors from amorphous or disordered materials, like common glass or silicon alloyed with less-costly elements. Amorphous silicon made possible the production of devices that are now inexpensive and ubiquitous in computing and energy applications.

"He invented the field of disordered materials," says Hellmut Fritzsche, former chairman of the physics department at the University of Chicago. "It was so revolutionary at the time that people at Bell Labs and other major research labs said, 'This man is crazy.' Stan's contribution was to say that [crystalline material] is not necessary, and it is too restrictive. You can make semiconductor materials in many ways when they are not crystalline, when they are disordered. Then you have a great freedom to alter their properties by chemical modification."

Soon a phalanx of physicists, chemists, and engineers were making a pilgrimage to the Ovshinskys' modest Detroit lab, including a young Robert Noyce and Gordon Moore, who were then planning a company to produce computer memory products, the future Intel Corporation. Many who came to scrutinize Ovshinsky's work stayed on to collaborate, captivated as much by Stan and Iris's lively warmth as by the novelty of the science. Fritzsche and others who have known him over the years say he always exuded a remarkable confidence in his own abilities.

Ovshinsky made his major discovery while trying to develop an artificial neuron as the first step toward developing a cognitive computer, a working model of the cerebral cortex that he still dreams of completing one day. But he soon put the discovery to work. In September 1966, he filed the first patent on phase change technology, which enabled a new type of computer memory. The most common type of computer memory is dynamic random access memory, or DRAM, which replaced the magnetic core memory of the earliest digital computers. But DRAM chips lose their data when the power is switched off. Phase change memory, which Ovshinsky called ovonic unified memory, registers data by changing the physical characteristics of the semiconductor material, from amorphous to crystalline and back again, and that change remains in effect even without electrical current. When a cell phone user's battery dies, but the phone retains her contact list, she has Ovshinsky's invention to thank. The same basic technology underlies rewriteable optical discs, enabling consumers to download music onto CDs.

Driven by the joy of discovery and their stated intention to use science and technology to solve serious global and societal problems, Stan and Iris kept the company small and nimble by licensing their technologies to major manufacturers. Profits were poured back into research, and growth came almost despite the founders' intentions. Energy Conversion Laboratory licensed its phase change technology to Intel and STMicroelectronics NV, both of which continue to develop and improve such chips.

The big change to the company came when Ovshinsky applied amorphous materials technology to solar energy. In 1983, when he first began to explore the field, photovoltaic cells were still the size of a thumbnail, and made of costly crystalline silicon in small volumes. To considerable skepticism, even within his own company, Ovshinsky insisted that photovoltaic materials should be made of amorphous silicon deposited on flexible plastics by the mile, like newsprint rolling off a press. The deposition process requires high vacuum and absolute isolation from outside contaminants that the manufacturing equipment of the day could not achieve. But Ovshinsky was first and foremost a machinist, so he designed and produced his own tooling. Reflecting its move into mass production, the company changed its name to Energy Conversion Devices, or ECD.

With the success of its solar panels, ECD entered a rapid growth phase that took revenues from a few million dollars a year into nine figures, and the employee roster from perhaps two dozen close associates to more than 1,000. Ovshinsky was now a manufacturer and manager of a large corporation, two roles he had never sought, and for which his iconoclastic temperament proved an awkward match. Although his company had gone public two decades earlier, in the 1960s, its small size and relatively slow growth had kept it below Wall Street's radar. With the growth and profitability of solar products came increased attention from securities analysts, as well as pressure to concentrate on cash generation. Ovshinsky simply ignored the pressures.

Stan Ovshinsky in 1969 at the Energy Conversion Laboratory in Detroit, Mich.

Photograph © Time & Life Pictures/Getty Images

Batteries and Betrayal

For Ovshinsky, a clean-energy source begged for a clean-energy storage solution, but the batteries of the time were highly toxic, endangering workers' health and the environment. He responded by inventing a rechargeable nickel–metal hydride (NiMH) battery, made of nontoxic and recyclable (and less expensive) materials. NiMH rapidly displaced nickel-cadmium cells in portable electronic devices, and in 1992 the U.S. Advanced Battery Consortium selected the Ovonic Battery Company, a subsidiary of ECD, to scale up its NiMH technology for electric vehicles. Ovshinsky's battery technology still powers the Toyota Prius and Honda Insight hybrid cars, though more recent electric vehicles like the Tesla Roadster and Nissan Leaf use lithium-ion batteries, a newer technology developed for cell phones and laptops.

In December 1996, GM began a limited launch of its EV1 pure electric car. The California Air Resources Board (CARB) then agreed to delay implementation of the first phase of a zero-emissions vehicle mandate that had been scheduled to go into effect in 1998, ordering that the seven biggest carmakers — the largest of which was GM — would need to make 2 percent of their fleets emissions-free by 1998, 5 percent by 2001, and 10 percent by 2003. Powered by lead-acid batteries, the first-generation EV1 had a range of 70 to 100 miles.

What should have been Ovshinsky's greatest triumph came when General Motors selected his tiny company over 60 other bidders to provide batteries for the second-generation EV1 in 1999. His battery doubled the EV1's range to 140 miles. GM acquired a majority stake in the company, changing the name to GM Ovonics, and the future looked bright. Robert Stempel, who wrapped up a 37-year career at GM as chairman and CEO in 1992, joined ECD Ovonics as an advisor in 1993, and became chairman in 1995. *Time* magazine called Ovshinsky "a hero for the planet." But General Motors was ambivalent about the EV1, and its small base of early adopters.

As shown in the documentary film *Who Killed the Electric Car?* oil industry groups lobbied successfully to end California's zero-emissions mandate. In the meantime, GM sold its stake in GM Ovonics to Texaco, which in turn was acquired by Chevron. Despite candlelight vigils by EV1 owners, GM recalled all its leased electric cars and crushed all but a few, which were donated — minus their drivetrains — to museums.

"It's a maze of betrayal," says Ovshinsky. "We had an agreement that if Texaco was bought out, we could withdraw, but they lied to us. They said, 'We'll support you, make it happen.' Within months it was obvious they weren't going to do that. As soon as possible they got me off the board."

In fairness to GM, which has clearly made its share of mistakes, the arithmetic supports the company's argument that the EV1 was not commercially viable at the time. GM based the leases for the EV1 on an initial vehicle price of US$33,995, with lease payments ranging from $299 to $574 per month, depending on state rebates. Industry analysts estimated the production cost of the car at as much as $100,000. In justifying its decisions, GM said some EV1 parts suppliers had quit, making it hard to guarantee future repairs and safety. Nonetheless, with the benefit of hindsight, and given the subsequent volatility of gasoline prices, some GM executives' opinions of the EV1 have changed. Former chairman and CEO Rick Wagoner told *Motor Trend*

magazine in 2006 that his worst decision during his tenure at GM was "axing the EV1 electric-car program and not putting the right resources into hybrids."

The rest is history. Japanese automakers seized the lead in hybrid gas/electric vehicles using NiMH batteries, although only after Panasonic EV, a joint venture between Matsushita and Toyota, settled a patent infringement suit brought by Cobasys, the successor company to GM Ovonics.

His treatment by "Big Oil" chastened Ovshinsky and made him wary of corporate partners, but he pressed on to develop the missing components of what he came to call the hydrogen circle, by making it possible to use hydrogen to power automobiles and other vehicles. Hydrogen is the most common element in the universe and the most abundant potential source of clean energy; a car fueled by hydrogen is completely emissions-free. But on earth, all hydrogen is bound to other molecules. Separating hydrogen from carbon in fossil fuels, most commonly natural gas, requires reformation, which consumes energy and releases carbon dioxide into the atmosphere, exacerbating the global warming that hydrogen-based energy is supposed to ameliorate. Transporting hydrogen requires chilling it to liquid form, which is energy-intensive and expensive, or compressing it under high pressure, which is potentially dangerous and requires heavy tanks.

To produce abundant hydrogen gas that could be used to power vehicles, Ovshinsky invented a technology he named Ovonic BioReformation. It is a single-step reaction that produces carbonate, a solid widely used in industry, instead of CO_2; takes place at low temperatures requiring less energy; and can be performed using a variety of fuels, including biomass. To tackle the transport issue, he developed low-pressure metal hydride containers, which absorb and release hydrogen like a sponge, and, for the U.S. military services, demonstrated a mobile refueling system requiring no costly infrastructure. This was typical Ovshinsky: No single invention stands alone.

The next step was to develop a new type of hydrogen fuel cell, a device that generates electricity through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte. Ovshinsky's fuel cell operated at lower temperatures than others, and without the costly platinum catalysts commonly used in these technologies. For those not willing to wait for fuel cells, he installed one of his metal hydride canisters in an ordinary 2002 Toyota Prius and ran the internal combustion engine on low-pressure hydrogen. Colleagues recall a visiting Toyota engineer looking on in disbelief until he finally cupped his hands beneath the exhaust pipe and tasted the pure water it emitted. Interest in hydrogen fuel cells has waned with the reduction in U.S. government research funds and with the industry-wide move toward electric vehicles and hybrids. However, some auto executives still insist the fuel cell is the technology with the greatest future potential.

In the midst of his technological advances, Ovshinsky ran headlong into an obstacle not described by the laws of physics: corporate governance regulation in the post-Enron age. He had always packed ECD's board with Nobel Prize winners and world-renowned thinkers in diverse fields whose attendance was clearly more related to mutual intellectual stimulation than legal and regulatory compliance. After the passage of the Sarbanes-Oxley Act in 2002, he had to take on additional outside directors with government-mandated skill sets, who then pressured him to emphasize quarterly earnings at the expense of experimentation. He was also forced to impose a reporting hierarchy on the company, which had never known titles or more than two levels of separation between the lowest-paid employee and the CEO. The culture of the company, which had always been collegial, became more conventionally corporate. Longtime colleagues began to leave, and Ovshinsky found himself dreading days filled with meetings and administrative duties. When Iris died suddenly in 2006 at 79, after an apparent heart attack, he abruptly retired.

It was not necessarily the board's fault. ECD's technological lead had never translated into sales leadership, and companies not distracted by forays into hydrogen research or other intriguing technologies claimed a greater share of the photovoltaic market. Although ECD's sales continued to grow at a steady pace, its 2009 revenues of $302.8 million pale in comparison to the $2.1 billion of market leader First Solar.

Ovshinsky says ECD would not have fallen behind had the board listened to him, and notes that the company's share price has fallen only since his departure. In the later years, he says, he not only had to fight to preserve his research budget, but also had to battle his own executives to develop the 30-megawatt production lines that are now ECD's greatest asset.

"The ECD machine I developed is larger than a football field, runs 24/7, and makes miles and miles of photovoltaics," Ovshinsky says. "When I said I was going to do that, we had only 5-megawatt machines. I lost

Ovshinsky ran headlong into an obstacle not described by the laws of physics: corporate governance regulation in the post-Enron age.

Iris and I lost the company at about the same time. The company I could have absorbed, but Iris was a deep, deep part of me."

A Cultural Innovator

Stan Ovshinsky always made a point of giving Iris equal credit for his insights and inventions, and longtime colleagues say she was also at least as responsible as he for the remarkably collegial corporate culture at ECD.

Before Sarbanes-Oxley, formal titles, reporting hierarchies, and standardized appraisals were nonexistent. A promotion simply meant taking on more responsibilities, and new hires were constantly encouraged to work outside their specialties or to take on tasks that challenged their skill sets. Many a chemist discovered a flair for physics, and a clerical worker could rise to senior management. Although the Ovshinskys did not use the rhetoric of participative management or nonhierarchical organizations, ECD embodied both concepts.

"My mom joined as a secretary when she was 35, after being a housewife forever," recalls Joichi Ito, CEO of the Creative Commons, whose parents both worked for ECD for many years. (See "The Ambassador from the Next Economy," by Lawrence M. Fisher, *s+b,* Autumn 2006.) Ito himself, now a globe-trotting venture capitalist and digital activist, began working at ECD as a teenager, and says that Stan Ovshinsky became a combination mentor and surrogate father to him after his parents' divorce. His mother "quickly became head of personnel, then vice president of international sales and licensing, and then was sent to Japan to be president of the Japanese division, and became the chief negotiator with the Japanese clients who were the biggest slice of the royalty fees for the technology."

Although ECD's growth over the decades gave many employees a comfortable nest egg, it was slow and steady and never generated the kind of intense, instant wealth that rewarded employees at firms like Microsoft, Google, or Facebook. Headhunters often recruited the company's multitalented engineers with promises of rapid riches, and some accepted lucrative offers only to find they missed the ECD culture.

"ECD was a reflection of Stan and Iris's personalities, and each one of us was an integral part of the firm," says Boil Pashmakov, who left ECD to work in the semiconductor industry and has now returned to work in Ovshinsky's new company. "In Silicon Valley, it is all about the money."

But notwithstanding Sarbanes-Oxley, Ovshinsky sometimes showed a side of his character that suggests he should not have been at the head of a publicly traded company. Like many a high-tech entrepreneur, he might have prospered more by taking the role of chief scientific officer while handpicking a cadre of professionals to manage the company. "He truly has a different set of beliefs. He's out to change the world, and he doesn't care about the money," says Patrick Klersy, another ECD veteran who has joined the new venture.

Starting Over

After his retirement, Ovshinsky languished for a year. He says he felt he was waiting for his life to end. Then in 2007, in short order he married Rosa Young, a Ph.D. physicist who had worked at ECD since 1986, and launched his fourth company.

Rosa says that Ovshinsky's proposal of marriage came as a surprise. She had already resigned from ECD herself, accepted a professor's position in Sich-

Ovshinsky's goal is a machine capable of producing a gigawatt per year of solar capacity, which is more than the output of a typical nuclear plant.

uan province in southwestern China, where she was born, and purchased a small apartment there. But, she adds, Ovshinsky has been surprising her for nearly 25 years now, never more than when he hired her in the first place, and then put her in charge of projects far removed from her academic background.

Few of Ovshinsky's old colleagues were surprised, however, when he announced plans for a new company. Considering the spotlight on global warming and renewed concerns about dependence on petroleum products, he simply could not remain on the sidelines. President Barack Obama's appointment of Steven Chu, a Nobel-winning physicist, as secretary of energy appeared to signal a fresh opening for sustainable energy development, and Ovshinsky felt he had to contribute.

Ovshinsky bootstrapped Ovshinsky Solar with $3.5 million of his own funds, and is now seeking $16 million in new capital to move from proof of concept to a small production facility. He says he will need an additional $350 million to reach full-scale manufacturing by 2012. The goal is a machine capable of producing a gigawatt per year of solar capacity, which is more than the output of a typical nuclear power plant, and more than 30 times the output of the largest current production lines at any photovoltaic manufacturer.

"Other people's idea of a gigawatt is to do it serially — build one machine and then another and another," says Ovshinsky. "If you look at all the cost and time of doing that, you are never going to get there. You can actually put a couple of our gigawatt machines in an ordinary factory. My costs will be lower than burning coal. That means pennies per watt. And that's the world revolution that's needed."

Increasing solar capacity requires improving the conversion efficiency of the semiconductor materials used or increasing the coating rate in production. It is presently impossible to have both high efficiency and high speed, and current manufacturing processes can be improved only incrementally.

Rosa Young and Stan Ovshinsky in 2010

Characteristically, Ovshinsky says he has found a way to push both parameters at once, and by significant amounts. "Our technology is a transformational advance in photovoltaics, combining higher conversion efficiency with 100-fold faster deposition rates," he says. Indeed, his tiny pilot plant recently achieved this milestone, sustaining a deposition rate of more than 300 angstroms per second, compared with 1 to 5 angstroms per second in state-of-the-art commercial photovoltaic processes. That increase alone would allow the building of a 1-gigawatt

capacity plant, but Ovshinsky says he will also soon announce a commensurate increase in conversion efficiency from the current level of about 10 percent.

Ovshinsky Solar currently has eight employees, all of whom had been at ECD for 25 years or more. They work in a tiny unmarked lab packed with elaborate instrumentation and prototype vapor deposition equipment of their own devising. A convoluted maze of stainless steel, the apparatus looks like a science fair project on steroids. The company has 14 patents pending, with more in the pipeline, but until they issue, Ovshinsky explains that he has to remain circumspect about exactly what he is doing. The breakthrough, he says, rests on the invention of an entirely new amorphous material — not a refinement of something he has done before — adding that his aha! moment came when he looked beyond the narrow science of solid-state physics as practiced today, much the way he did 50 years ago with the discovery of amorphous materials. "If you're going to do something new, you have to overlap fields," he says. "God didn't make disciplines; man did."

The capital sums Ovshinsky is seeking are not big relative to the billions that venture capitalists are throwing at green energy startups, but he says he is not looking to them as investors. "Why don't I go to the venture capitalists? They don't care about the achievement; they care about getting out of it at the right time," he says. "I think countries are better. All they want is for you to build the machines. I prefer to get money from groups that want to answer the problem, and that understand that it has to be revolutionary."

Ovshinsky won't say which governments he is talking to about funding, but a glance at his calendar shows that he has been traveling a great deal, particularly to China. Chinese solar panels accounted for about half of total worldwide shipments in 2009, and that share is expected to grow. "China is doing the right things," Ovshinsky says. "They have lots of good people, and they have a plan for energy. We do not have a plan for energy."

Silicon Valley venture capitalists say that although Ovshinsky's achievements are well known to them, so is his reputation as a difficult partner for investors. And they caution that he would find Beijing and Sichuan investors no easier to work with than venture capitalists in northern California.

"No matter what he's come up with, people will pay attention because he has a track record of some pretty impressive breakthroughs," says Sunil Paul, founder of Spring Ventures, a San Francisco–based fund that invests in and incubates clean-energy technologies and companies. "But Stan does have this complicated reputation; you want him to be Edison, but there's a risk he'll end up being Buckminster Fuller."

For longtime participants in the solar industry, Ovshinsky's ability to deliver a breakthrough technology is not in doubt, despite the magnitude of the advance he is claiming. They say the economic and environmental case for low-cost solar power is so compelling that it is almost inevitable but building a 1-gigawatt machine is only the first step in a long road to market. "I don't know what technology he's using, but it's not something we know anything about," says Travis Bradford, author of *Solar Revolution: The Economic Transformation of the Global Energy Industry* (MIT Press, 2006). "It's not a current-generation technology. And that next gen is five to 10 years away. Then there are business model problems, even if he can build a gigawatt line."

At 88, Ovshinsky is well aware of the actuarial tables, and though he plans to go on working for years, he has structured the new company so that it can function without him. But it's also clear that he cannot function happily without a group of like-minded souls striving to take his concepts forward.

"I never did this for awards, money, power," Ovshinsky says. "I did it because it had to be done, and because of my social drive to make a better and more beautiful world. That's what I started doing when I was knee-high, and I don't expect to stop now." +

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Resources

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Stan Ovshinsky's Facebook page, www.facebook.com/pages/Stan-Ovshinsky/320093792727

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