ENERGY

A Revolution Fueled by the Sun

by Avery Cohn

Can the world afford to solve climate change as the global economy slows? According to renowned physicist and inventor, Stanford Ovshinsky, alternative energy that addresses climate change is not just an environmental imperative, it's also the best path to revive the global economy and refashion it to better serve people. And, the alternative energy technologies hold promise for both development and the environment in Latin America.

In a wide-ranging talk before a packed audience in the Morrison Room of Doe Library, Ovshinsky emphasized that a great many energy solutions are no longer far-fetched ideas but rather proven options, lacking only political will to go to scale. "Forget a new Manhattan Project," he urged, "there [are] solutions… and they are not 20 years away. They are here now."

Ovshinsky ought to know. He has spent more than five decades pioneering the science and inventing the technologies needed to carry out an energy revolution. This may explain why he calls his revolution a conservative one:

Stan Ovshinsky at UC Berkeley.

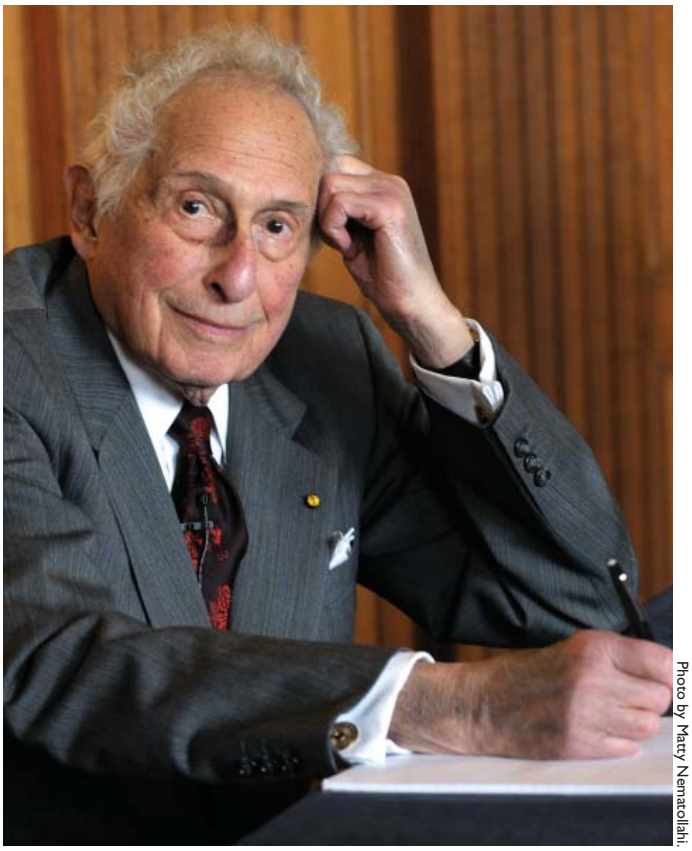

Photo by Matty Nematollahi.

he's been carefully building and testing it for half a century. It is, he argued, rooted in proven technologies, not an abstruse, hopeful vision. "In God we trust," he quipped, "everyone else must show data."

For the uninitiated, the data on Ovshinsky is mind-boggling. He is a renowned scientist with over 300 peer-reviewed publications, most of which are in physics, a field he began mastering in the Akron, Ohio Public Library. And though he has lectured in universities throughout the world and counts Nobel Prize winners among his friends and collaborators, Ovshinsky's own formal education ended when he started working as a machinist in Akron right out of high school and trade school. .

Best known as an inventor, Ovshinsky holds over 350 patents. The company he founded, Energy Conversion Devices, Inc., currently runs four thin-film solar manufacturing facilities able to produce miles of solar panels a year. Resembling enclosed printing presses a football field long, the four Michigan plants will be able to produce enough solar panels to move 50,000 houses a year off the electricity grid. And these plants are likely just the beginning.

Greening the auto industry has long been one of Ovshinsky's goals. After inventing the nickel metal hydride battery, which powers the Toyota Prius and almost all hybrids sold today, he went one better than Toyota by modifying a stock Prius to run entirely on hydrogen. The fuel tank is filled with a solid material Ovshinsky atomically engineered to absorb hydrogen delivered from an innovative fueling station he also designed. The car handles like a conventional Prius — with possibly more spirited acceleration — and provides range comparable to many contemporary vehicles. Most importantly, Ovshinsky's hydrogen vehicle is straightforward to manufacture. The hydrogen itself can be generated from renewable sources such as solar or wind or from conventional power plants during off-peak hours at night.

The hydrogen Prius and the rest of Ovshinsky's opus are the product of a plan he and his late wife Iris devised almost 50 years ago. In the energy sciences there is a concept called "well to wheels" that refers to the entire scope of an energy system: generation, storage, infrastructure and use. In 1960 the Ovshinskys resolved to fill each of these niches with technologies that use what Stan calls the ultimate fuel — hydrogen. Now their plan is a reality. Their solar panels

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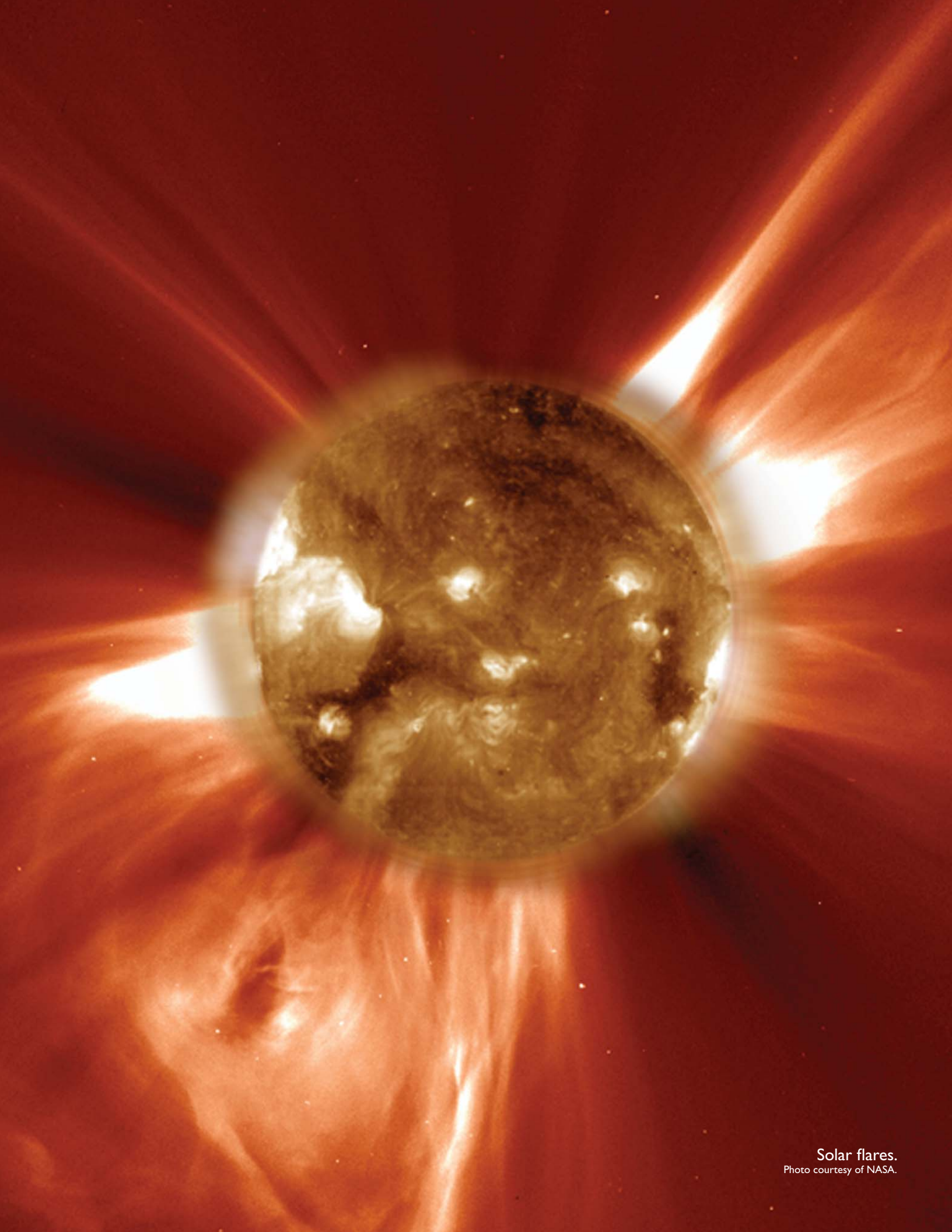

Solar flares.
Photo courtesy of NASA.

harvest the sun's photons, a byproduct of the fusion of hydrogen and the sun; their innovative materials restore the energy as hydrogen; and their modified Prius runs on this hydrogen in a process Ovshinsky calls the hydrogen loop.

"When you use hydrogen and the sun you're completely decoupled from fossil fuel," Ovshinsky said in his presentation. "You're coupled to the big bang and [hydrogen] the most common element in the universe."

These inventions are all built on a backbone of innovative materials called Ovonics that Ovshinsky began experimenting with in the 1950s. The "experts" at Bell Labs said there was no future in the field of amorphous and disordered materials. The timeline accompanying this article depicts Ovshinsky's vision and accomplishments which were consistently years, and sometimes decades, ahead of the rest of his colleagues in science and industry.

In a glowing introduction to the Ovshinsky talk, former vice provost and dean of research and graduate policy at Stanford University and American Physical Society president Dr. Arthur Bienenstock explained that both literally and

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One of four plants that produce thin film solar cells by the mile.

Bienenstock Introduces Ovshinsky

In the mid-1960s, Stan had an enormous impact on physics with the announcement of two types of devices. Both involved conductors with a thin sheet of amorphous material in between. By applying pulses of one sort, he could transform that thin sheet from a highly resistant material to a highly conducting material. It was known as the threshold switch. It would have a very high resistance until a certain voltage was reached, and then it would switch to a highly conductive state.

Photo courtesy of Energy Conversion Devices, Inc.

The second device was a memory device. Again, it involved switching from a high resistance state to a lower resistance state, but this time, you could keep it in either the high or the low resistance state without the application of an electric voltage. Those two devices got the field of amorphous semiconductors going. At first no one believed that you could go back and forth between a high and low resistance state as rapidly as Stan was claiming. And Stan was also claiming that it was a transition back and forth between a crystalline state in which the atoms are highly ordered and an amorphous state in which the atoms are ordered pretty much like a liquid. Stan was subsequently proven to be right, however. And the field progressed.

Soon after that Stan showed that you could switch these materials with the application of light, and in particular, lasers. And most of you in the room profit from that because it's the basis of the CD-RWs and the DVD-RWs that you use on your computer. They're all based on the type of memory materials that Stan developed.

At the same time, Stan was making fundamental contributions to the field of amorphous materials, throwing ideas out just left and right. I can recall being on a plane with the Nobel Laureate Sir Nevill Mott, who got his Nobel Prize for working in this field; he said, "A lot of my best ideas came from Stan. He just gave them away to me." And all of us in the field have had that experience.

Stan's next project was using amorphous silicon to make photovoltaics. He made fundamental contributions that converted it from a lab phenomenon to something that became commercial, ending with production plants that manufacture photovoltaic sheets about a yard wide and a mile or so long that you can slice up to put on roofs and the walls of buildings. This development dramatically changed the photovoltaic field from something where you powered little calculators to something that could produce lots of power.

I think it was in the 1980s that Stan developed the electrodes for the nickel metal hydride battery. Before that people were trying to make pure, single phase electrodes; Stan brought disorder to the field, putting many elements into the battery so that the crystals were very small. And that allowed the capacity of the batteries to become so high that they could be used for all of the nickel metal hydride cells that you have in your computers and also in hybrid automobiles. He used the same ideas to advance hydrogen storage — in solids, not in gas tanks — and in fuel cells. And with that, I think I will quit and leave the floor open to Stan.

Arthur Bienenstock is Professor of Materials Science & Engineering and of Applied Physics at Stanford University. Formerly he served as Provost and Dean of Research and Graduate Policy, and is past president of the American Physical Society.

Photo courtesy of Energy Conversion Devices, Inc.

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figuratively Ovonics "brought disorder to the field" of materials science.

The literal disorder is that Ovshinsky's materials are amorphous or seemingly disorganized as opposed to the regimented crystalline patterns favored by many competitors. The figurative disorder is that across a broad array of applications, from recordable CDs to Prius batteries, Ovonics outperform their crystalline competitors. Ovonics may eventually prove figuratively disordering to the business models of some energy titans as well because their unique physical structures allow them to be cheaply mass produced and, therefore, to compete with conventional sources of energy.

And so the hydrogen loop also carries a powerful political charge. The technologies Ovshinsky has invented can help to prevent climate change, but they may also disrupt livelihoods and business models. This reality has forced Ovshinsky to step carefully. As he explained, "I was quite upset when they crushed the electric cars… but I want to be a resource to them. There are hundreds of thousands of people without jobs." He has a strong conviction that the auto industry can reinvent itself to once again provide numerous, well-paid jobs and revitalize manufacturing. Ovshinsky remains committed to developing technologies that strike an appropriate balance between decent jobs and environmental stewardship.

The winds of economic change blowing through Detroit are hardly atypical. In a series of columns in the New York Times over the last two years, Thomas Friedman has argued that while climate mitigation technology innovation can begin in the U.S., it can only succeed by finding markets in developing countries where energy demand is growing the fastest. Ovshinsky takes Friedman's logic one step further, asserting that emerging economies can deploy alternative energy technologies in partnership with industrial economies, propelling development as well as providing energy.

During his talk, Ovshinsky argued that the current boom in global commodity prices is an opportunity for resource-rich nations to strategically invest in energy alternatives. He recounted how when he was invited to visit Venezuela by the oil industry during the energy crisis of the 1970s, he urged government officials there to invest windfall oil profits wisely. "Those hills are your future," he said as he pointed to the ranchos (hillside slums), "build new industries; provide jobs for the people that are up in those hills." Ovshinsky is again calling for nations growing rich through the extraction of natural resources to courageously invest in innovative new ways to break their dependence on fluctuating commodity prices.

Creating the institutions to productively capture the value of resource extraction is, of course, easier said than done. Scholars such as Stanford sociologist Terry Karl argue that an abundance of certain kinds of natural resource wealth can be a curse that may engender corruption and deepen inequality. Designing an energy sector that improves social welfare is a substantial challenge; creating such a sector that also fights climate change will require courage, creativity, strong will, and collaboration from governments and businesses.

Ovshinsky is acutely aware that his life's work only just begins to address climate change. He has recently retired from Energy Conversion Devices in order to establish a new firm, Ovshinsky Innovations, so that he can once again focus on breakthrough scientific discoveries. Discoveries, he says that the world urgently needs.

He seems delighted to be joined in his work by an emerging generation of clean energy scientists. During the question and answer session following his talk he enthusiastically fielded questions from several students doing basic research, as he once again is doing, on emerging energy alternatives. While he put their science and technologies through his exacting paces, he encouraged the students to keep to their vision. "No one should be prevented from trying anything, not even by me. I may be a revolutionary, but I've always been a fairly conservative revolutionary."

In a lunchtime discussion with eminent scholars during his visit to UC Berkeley, Ovshinsky made clear that despite his unconventional path to discovery and acclaim, he firmly believes in the promise of formal education. But, he cautioned, only when creativity is allowed to flourish and a little disorder is allowed to creep in will the academy be a key contributor to the energy revolution he has begun.

Stanford R. Ovshinsky has been at the forefront of alternative energy innovation for almost 50 years. He has recently founded Ovshinsky Innovations LLC to develop breakthrough technologies to mitigate climate change. He spoke at CLAS on April 8, 2008.

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Rosa Ovshinsky, Harley Shaiken, Sara Lamson and Stan Ovshinsky on the UC Berkeley campus.

Photo by Matty Nematollahi.

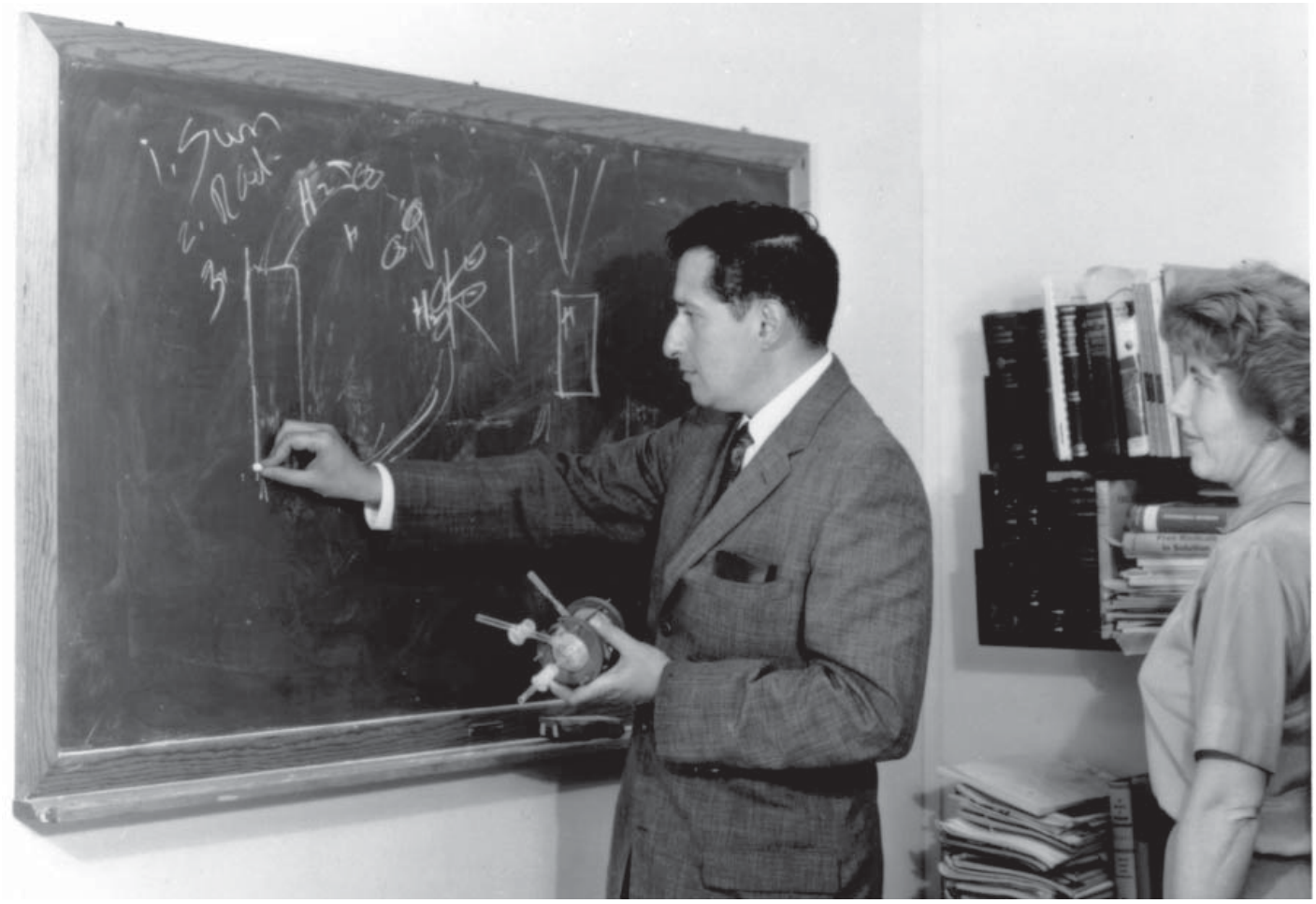

Photo courtesy of Stanford R. Ovshinsky.

Stan and Iris Ovshinsky diagramming the hydrogen loop in the 1950s.

ENERGY

Detroit's "Imagineer"

by Harley Shaiken

I first met Stanford Ovshinsky as the sixties began to unfold. I was 15 and Stan, as he always liked to be called, was the most remarkable person I had ever met. He was a brilliant scientist and inventor who passionately wanted to change the world. And now, almost five decades later, I would not change my assessment about him except to add that he has succeeded in changing the world in remarkable ways.

One can get a sense of Stan by starting at his home, a warm, beautiful place at the edge of a small lake north of Detroit. Among the many photographs throughout the house that chronicle an amazing life, I'd like to focus on three. The first is a photograph of I. I. Rabi, the great Nobel Prize-winning physicist, with a warm inscription to Stan; the second shows Lázaro Cárdenas, modern Mexico's most beloved president, signing a land reform decree in the 1930s as three peasants look intently over his shoulder; and the third is of Stan having dinner with Rosa Parks, the hero of the civil rights movement. These photographs underscore three themes that run throughout Stan's life: his scientific brilliance, his social vision and his moral courage.

Stan's scientific work has been path-breaking. The Nobel-winning Rabi referred to his contribution as "stunning and monumental." When Rabi was asked if Stan was another Edison, a singular complement on its own, he is said to have replied "He's an Ovshinsky, and he's brilliant." As a 2008 profile in the New York Times Magazine put it, "Ovshinsky is a systems thinker who envisions the future as it should be — and then goes out and invents the scientific tools and technological wizardry needed to bring it to life."

Stan began his career working on automation. From there, he moved on to do original, highly regarded work on the treatment of schizophrenia with organic drugs. In

the mid-1950s he again changed his focus and began defining the science and technology of amorphous or disordered materials. Stan's discoveries were not exactly embraced with open arms. According to the late Dave Adler, a highly-regarded MIT physicist, "Almost all physicists believed that amorphous semiconductors could not even exist." Stan's work, however, blazed a new trail, and the field that couldn't exist is now named Ovonics. It forms the basis for a "solar hydrogen loop" capable of harnessing and storing the sun's energy and creating a carbon-free energy grid. The result could define our era as the Hydrogen Age.

Energy Conversion Devices, the company Stan and his late wife Iris founded in a store-front in a declining area of Detroit in 1960, drew the best and the brightest from throughout the world. His laboratories became, for Hellmut Fritzsche, a close friend and former chair of the physics department at the University of Chicago, "a Mecca for many of us from Stanford, Harvard, MIT, Penn State and Chicago." Stan was able to translate his scientific advances into impressive technologies such as machines capable of turning out sheets of flexible, thin-film solar material by the mile; nickel metal hydride batteries that power virtually all commercial hybrid vehicles sold today; solid-state hydrogen storage; and innovative memory chips.

What makes these achievements all the more remarkable is that Stan did this pioneering work without formal credentials. Born and raised in Akron, Ohio, he dropped out of high school to serve an apprenticeship as a machinist. He did what one might call "postgraduate work" at the Akron Public Library at night. The significance of his work has at last begun to receive wide recognition. The American Chemical Society named

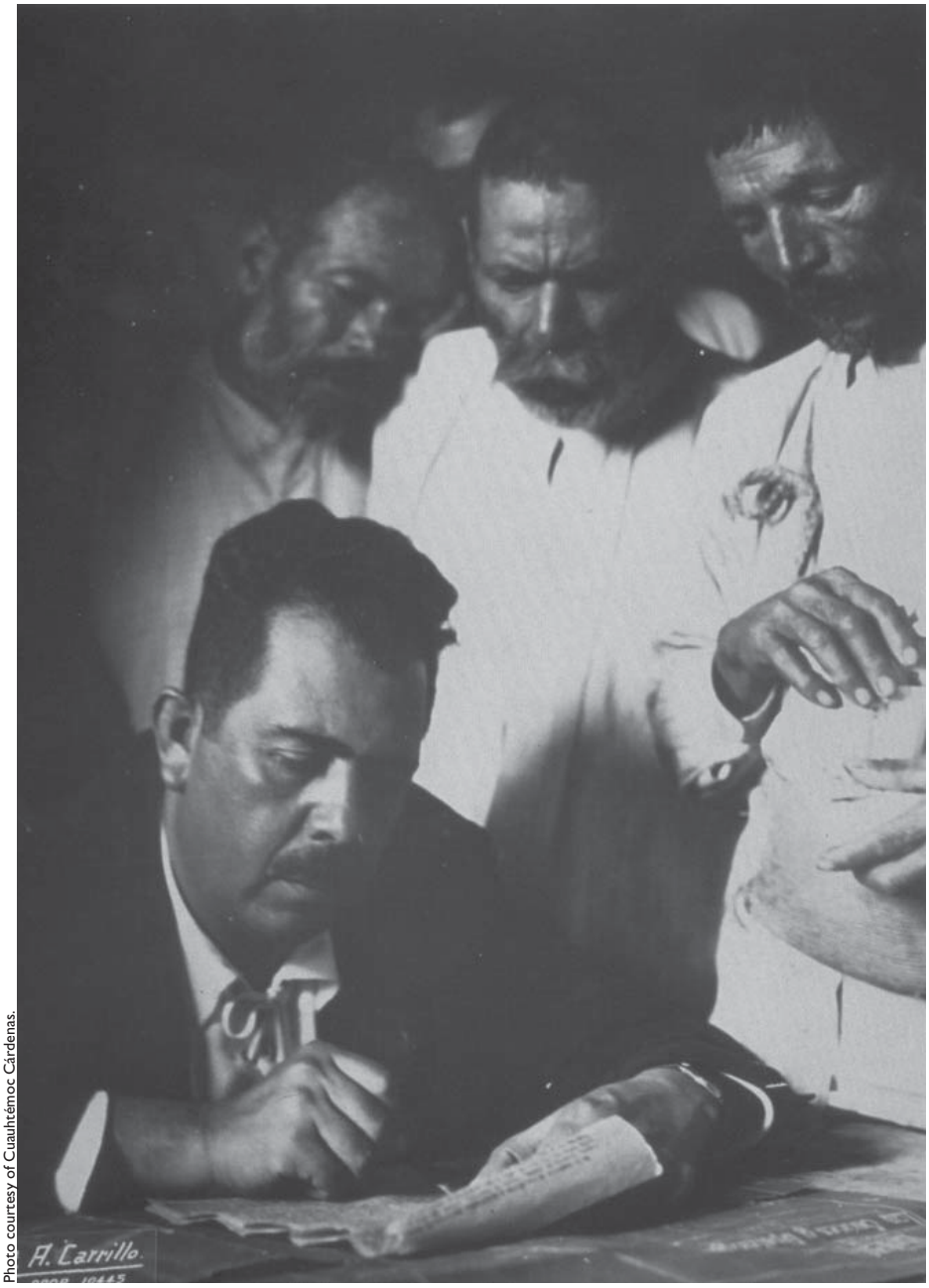

Photo courtesy of Cuauhtémoc Cárdenas.

President Lázaro Cárdenas signs an agrarian reform decree in Los Sauces, Guerrero in 1934.

him and Iris "Heroes of Chemistry 2000" for their "significant and lasting contributions to global human welfare." He is a Fellow in the American Physical Society and the American Association for the Advancement of Science and has won innumerable awards for his scientific research and technological accomplishments.

Stan's technical work is informed by his social vision: he wants to create a better world. The widow of President Lázaro Cárdenas gave Stan the photograph of her husband in recognition of what his work potentially means for Mexico and for Latin America. In fact, Stan often shows a photo of a Mayan woman climbing a hill in the Chiapas rainforest carrying her young child in front and a roll of his solar material on her back. "She is surrounded by the future," he likes to point out. Stan not only sees what electricity could mean to the villagers of Chiapas, he also envisions dynamic new industries capable of fueling Mexico's development.

Stan emphasizes the urgency

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Photo courtesy of Energy Conversion Devices, Inc.

The 2005 hydrogen-powered Prius.

of developing and implementing the "solar hydrogen loop" for three reasons: the specter of global warming, the geopolitics of fossil fuels and the possibilities of new industries generating employment. He argues that our continued reliance on fossil fuels has edged us toward the brink of irreversible damage to the planet. The economist William Cline points out that under plausible scenarios "global emissions of carbon dioxide will approximately double by 2050 and quadruple by 2100." One particularly damaging consequence is that agricultural potential could plummet 20 to 25 percent in Latin America and Africa by the 2080s, issuing in a new era of global hunger and dislocation.

As serious a concern is the geopolitics of fossil fuels: the growing demand and shrinking access to oil fuels conflict and war, hardly an abstract issue in the world today. The abundance of hydrogen removes a particularly volatile flashpoint between nations. "You're decoupled from fossil fuels," Stan says, "and coupled to the origins of the universe." And, finally, the production and installation of the "hydrogen loop" could create millions of jobs. In Latin America new industries could propel development, and in the United States they could propel prosperity. The New York Times featured a front page article in April 2008 about two communities in Michigan, one enduring the trauma of a plant closing and the other looking towards the creation of jobs from new solar energy plants built by the company Stan founded.

The theme of moral courage is highlighted by the photograph of Stan having dinner with Rosa Parks in Detroit. Willing to stand alone to develop scientific and technological principles, Stan has been equally courageous in defending the core values of a democratic society. He stood up when unions were organized in the 1930s; when Rosa Parks refused to give up her seat in the front of the bus, jump-starting the civil rights movement in the 1950s; and when democratic principles were under attack in Latin America in the 1960s and 70s. A commitment to civil liberties and human rights informs him as a person, as a citizen and as a scientist. And he does not draw a distinction between these various roles.

His commitment to working towards a better, more democratic world drove his work on alternative energy in the early 1960s. In retrospect, it took an unusual vision to found a company called Energy Conversion Devices years, if not decades, before the threat of oil shortages and climate change began to shape our lives. Stan says he doesn't mind being called

a visionary, just don't call him a dreamer. After all, he has produced the machines and products that have made his vision into something solid and functional.

Throughout his life, Stan has displayed strong optimism, but he's also realistic. Rather than being crushed by reality, however, he has sought to use his optimism and unique gifts to make a better world. To rephrase the great American labor leader Eugene Debs, "The cross is bending, the midnight is passing and joy cometh with harnessing the sun."

Harley Shaiken is Class of 1930 Professor of Letters and Sciences and the chair of the Center for Latin American Studies at UC Berkeley.

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Photo by Matty Nematollahi.