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. Such 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: 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."

Stan Ovshinsky at UC Berkeley.

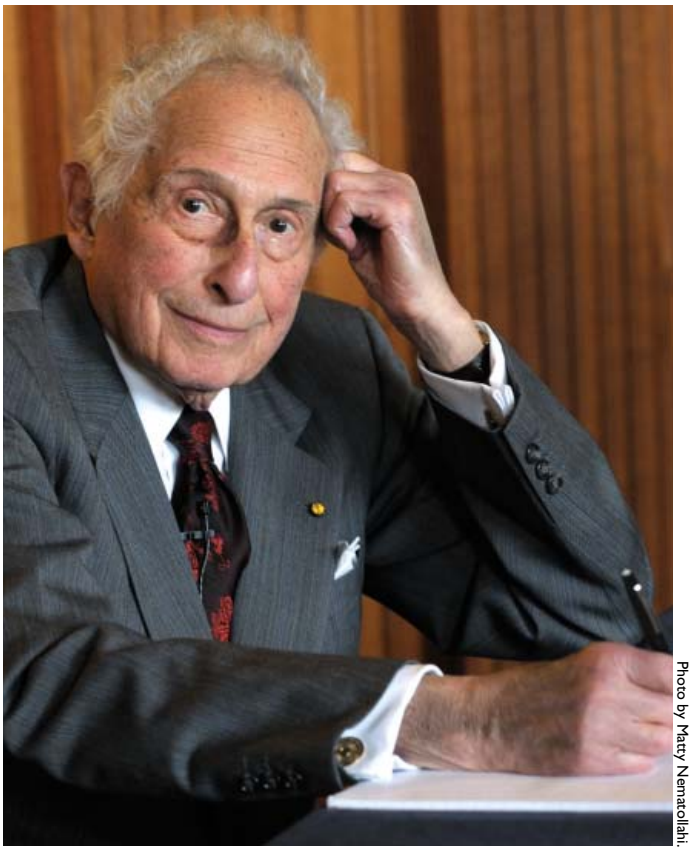

Photo by Matty Nematollahi.

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. 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 a 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

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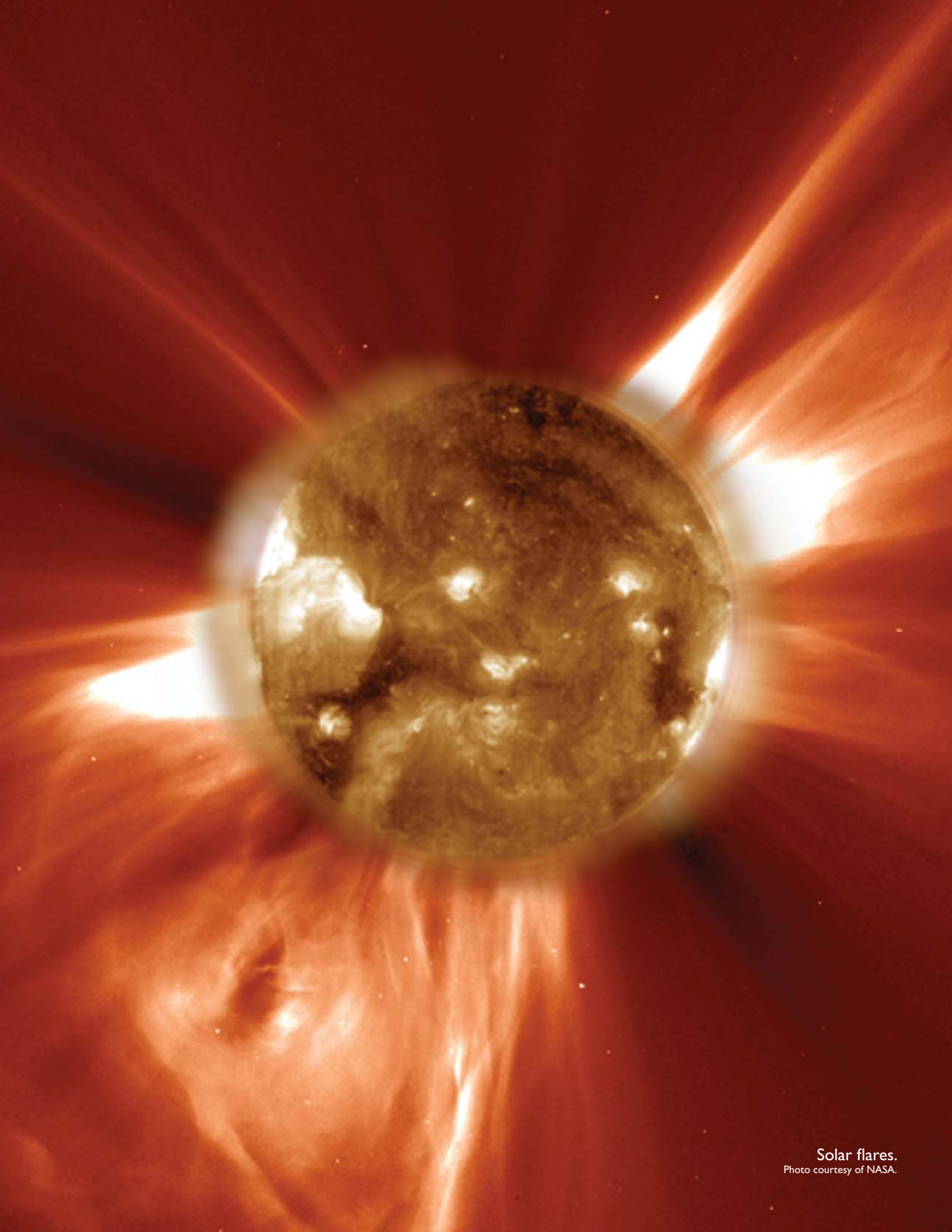

Solar flares.
Photo courtesy of NASA.

panels 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 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, a time when the "experts" at Bell Labs said there was no future in the field of amorphous and disordered materials.

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

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

Bienenstock on 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, Stan showed that you could switch these materials with the application of light and, in particular, lasers. This technology is the basis of the CD-RWs and the DVD-RWs used in computers. 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 that 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. This 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.

Arthur Bienenstock is Special Assistant to the President for Federal Research Policy at Stanford University, where he is a professor at the Stanford Synchrotron Radiation Laboratory and in the Departments of Applied Physics and Materials Science and Engineering. He is President of the American Physical Society and has served as Associate Director for Science of the White House Office of Science and Technology Policy. He has collaborated with Stan Ovshinsky since 1965.

Photo courtesy of Energy Conversion Devices, Inc.

Unrolling thin-film solar panels on a Los Angeles roof.

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 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 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 on emerging energy alternatives, as he once again is doing. While he put their science and technologies through his exacting paces, he encouraged the students to keep to their visions. "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.