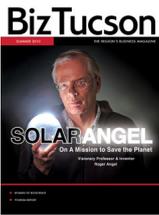


Solar Angel

Written by Larry Copenhaver

Wednesday, 16 June 2010 22:07 - Last Updated Wednesday, 06 October 2010 23:22



Going green. It's not so much about a color as it is about an attitude.

Green attitudes seem to be cropping up all over. Yet much of what's going green today, from recycling to producing clean electrical energy from wind or solar, comes with one common denominator – government subsidies.

Now the University of Arizona Regents Professor J. Roger P. Angel is certain he's discovered a way to produce electricity from clean solar in a manner that would be economically competitive with fossil fuels and ultimately supply the world's electrical energy needs – without taxpayers' money.

Angel is known for making his big ideas work. He is a pioneer in modern optics. He is the scientist who was integral in designing the world's largest telescope and inventing a revolutionary process to make large yet light telescope mirrors at UA.

Today, to execute his low-cost solar production plan, Angel can be found working at the bottom of an abandoned swimming pool behind "Bear Down" Gym on the UA campus.

That's where he has constructed a one-ton, two-axis sun tracker made of light-gauge pipes painted white. It's the superstructure for the first phase of a prototype for a solar-energy system he sees as the key to dramatically reducing the world's dependence on fossil fuels.

This system focuses concentrated sunlight on triple-junction photovoltaic cells. The cells can convert sunlight to direct-current electricity with the highest efficiency of any known method. Angel's clean-energy solution comes with no moving parts except the tracking device, makes very little noise and emits no pollution.

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Most solar cells are composed of silicon, the 14th element on the periodic table many learned about as sophomores in high school. Silicon is a semiconductor that has properties of both conductors and insulators. A semiconductor binds atoms tighter than metals but looser than insulators. When energy, in the form of photons from the sun, strikes solar cells, electrons break free and create a flow of electrons – known as electric current.

To further develop and market this solar energy solution, Angel and his scientific colleagues have formed a company called REhnu (pronounced renew). Their innovative technology is licensed from the UA. It is estimated to create electric current five times cheaper than the solar energy processes presently dominating the market.

Cost has to be controlled or else utility companies will not buy without government subsidies, Angel said during an interview in his office at UA's Steward Observatory.

One current process is the familiar rooftop photovoltaic panel also used on solar farms, the largest being the one at Nellis Air Force Base in Nevada that produces 15 megawatts of electricity.

The other current method, for generating large amounts of power, focuses concentrated sunlight on pipes to form steam that turns turbines, such as one in the Mojave Desert in California that produces 300 megawatts of power.

The capital costs of these conventional methods, around \$5 per watt, cannot compete with burning fossil fuels.

But Angel's technology does.

He has set a target for gigawatt-scale production at an installed capital cost of \$1 per watt, for an energy cost of 5 cents per kilowatt hour. His technology uses large mirrors to focus sunlight onto the small but high-output triple-junction photovoltaic cells.

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“We have just shaped a large square of glass into a deep dish,” Angel said. Tubing provides support for the 11-foot-by-11-foot deep-dish glass, the first of many for the project.

The glass units will be silver coated on the back much the same as a bathroom mirror, said colleague Peter A. Strittmatter, a UA astronomer, director of the Steward Observatory, and himself a noted scientist. The expectation is to reflect at least 90 percent of the sun’s energy, perhaps as much as 98 percent.

Strittmatter has worked with Angel for more than 35 years on projects including the development of the Steward Observatory Mirror Laboratory and much of the solar research. They know a lot about glass.

“We have tricks we learned from astronomy about handling glass,” Angel said.

Development of a competitive solar plan is vitally important, Angel said. “I regard global warming as a great threat to the planet, and I want to help save the planet.”

If carbon is the culprit contributing to global warming, which Angel assures it is, there is great benefit to his scheme.

For example, a one-gigawatt REhnu farm would generate no CO2 and use no water, while a one-gigawatt coal-fired plant emits five tons of CO2 every minute and consumes 10,000 gallons of water.

A gigawatt is a unit of electrical power equal to 1,000 megawatts or one million kilowatts. For instance, peak load in the U.S., on the hottest summer afternoons, is 800 gigawatts. The total energy produced annually by a one-gigawatt solar farm is about the same amount of energy consumed by 200,000 U.S. homes.

Angel concedes that carbon would be produced in manufacturing and installing a REhnu farm,

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but that amount would be paid back in less than two years. And every year after that, the farm would spare the atmosphere 2 million metric tons of CO₂.

Projecting into worldwide utilization, a thousand REhnu farms would reduce total global CO₂ emissions by 10 percent.

Compared to solar farms using standard photovoltaic panels, the environmental impact of REhnu's farms would be small, plus blading and leveling would not be necessary. Installation of the generators, which are set high above the ground, leaves most of the land undisturbed and largely unshaded.

Angel plans an assembly-line approach, much like the method used to keep car prices down. "We've got to be as mechanized as possible." Success is very much contingent upon large-volume use. It is not for individuals or single structures.

Keeping the total installed cost under \$1 per watt is mandatory if there is hope of operating at a cost low enough to promote adoption on a massive scale.

Meanwhile, the apparatus must distribute the same amount of concentrated sunlight to all the triple-junction photovoltaic cells so all generate the same electrical current. If one cell were to receive a significantly lower amount of concentrated sunlight, the system could shutdown much like a string of Christmas tree lights do when one bulb fails, he said.

To avoid that, a single large primary reflector focuses the light to power many cells clustered in the small receiver at its focus, and the optics in the receiver apportion the strongly focused light evenly among all the cells.

REhnu's business plan calls for starting a pilot production plant in 2012 at two megawatts per year. REhnu will team with manufacturers to reach 20 megawatts per year in 2014. Angel said he does not expect to reach the gigawatt level until 2020.

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The cost of setting up a gigawatt farm is estimated at \$1 billion. That cost, Angel said, is fully competitive with electricity from fossil fuels.

While in the initial, smaller-scale phases of development, REhnu would benefit from Renewable Energy Credits and solar investment tax incentives. Government subsidies are not part of REhnu's long-term business model.

Working on efficient solar energy "is something that lets me be at peace with myself," said Angel, the grandfather of two.

Tucson is a very special place for this kind of development, Angel said. Tucson has the conditions scientists seek.

"We have this unique convergence of a cutting-edge university, clear air, dark skies and the mountains," he added. Tucson is about the only place in the contiguous 48 states to offer such a sum of top qualities.

"We are perfectly placed," Angel said.

The university is excited about Angel's plan, said Leslie Tolbert, UA vice president for research. "Roger Angel is a worldwide phenomenon."

The UA is in the major leagues of physical science research. That's born out by a recent National Science Foundation report that ranks UA tops of 679 public and private universities in funding for the physical sciences, Tolbert said. "The NSF ranking tells us we're playing a leading role in the nation's physical sciences research effort."

In his nearly 37 years at UA, Angel, director of the Steward Observatory Mirror Laboratory and director of the Center for Astronomical Adaptive Optics, has had a leading role in accomplishing scientific wonders. His list of scientific developments includes two of the world's largest

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telescopes – the powerful Large Binocular Telescope (LBT), operating atop Mount Graham, and the Large Synoptic Survey Telescope (LSST), scheduled to capture first light in about four to six years in northern Chile.

At the mirror lab, Angel headed the development of the rotating furnace and honeycomb design of large mirrors, including the 8.4-meter behemoths for the LBT and the LSST.

The process, which actually began as an experiment in Angel's backyard in 1980, allows for polishing the deeply parabolic surface resulting in much shorter focal lengths than conventional types. Such mirrors improve telescope performance, yet fit into smaller, less expensive enclosures.

Angel's mirrors are as strong as conventional ones – and they can be significantly larger and dramatically lighter.

Air can be circulated through the lightweight honeycomb structure, forcing the glass to reach thermal equilibrium with the air temperature in a relatively short time, on the order of 20 to 30 minutes.

Angel's plan for commercially competitive energy from the sun is one of several global warming initiatives he has undertaken.

Another is his emergency plan that could literally put sunshades on the Earth to dampen the amount of energy reaching the globe from the sun.

He calls it solar radiation management.

The idea involves deploying trillions of space sunshades in the event that Earth was unmistakably headed for disastrous climate change within a decade or two. The shades would be small, light and extremely thin objects launched into a high Earth orbit, a million at a time.

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Once in orbit, the shades would be dealt off the stack forming a long, cylindrical cloud with a diameter about half that of Earth, and about 10 times longer. About 10 percent of the sunlight passing through the 60,000-mile length of the cloud, pointing lengthwise between the Earth and the sun would be diverted away from our planet.

Angel, a UA Regents Professor in both astronomy and optical sciences, figures such a program would uniformly reduce sunlight by about 2 percent over the entire planet, enough to balance the heating caused by a doubling of atmospheric carbon dioxide.

Angel says his mind is always working on solutions to problems of the planet. Whether in the shower, walking up stairs or driving, his brain is racing, pondering practical solutions to complex situations.

“Ideas? I don’t have to work at that,” he said. “The challenge is sorting out what will work.”

He said he gets inspiration for tackling big problems from his two scientific heroes.

One hero is Sir Isaac Newton, the 17th-century English physicist, who ground and polished his own telescope lenses and is credited for inventing the first reflecting telescope. The other is Galileo Galilei, the 16th-century Italian physicist, who championed Nicolaus Copernicus’ theory in the 15th century that planets orbit the sun, rather than the Earth being the center of the universe.

Galileo’s findings were politically controversial and led to him being forced by the Roman Catholic Church to recant his ideas. He spent much of his later life confined, virtually under house arrest for his scientific positions. Angel said that during a visit to Italy, he trekked to the place where Galileo lived out his life under confinement.

To many, Angel himself is a present-day scientific hero.

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Strittmatter said, “He has a huge reputation. He is a household name around the world in the astronomical context.

“He’s the driving force behind most projects. Roger has a wonderful grasp of physical science and a wonderful ability to get on with people. In his usual fashion, Roger has gotten to the issue of generating electrical power at a cost similar to what we spend on fossil fuels.”