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The New Nuclear: How A $600 Million Fusion Energy Unicorn Plans To Beat Solar

Walking with Michl Binderbauer into his 2-acre laboratory feels a bit like taking a factory tour with Willy Wonka. In one corner Binderbauer, chief executive of TAE Technologies, shows off a new machine that blasts cancer tumors with a neutron beam. Engineers huddle in a control room. Beyond their window: Norman.

That's the name of TAE's 100-foot-long prototype nuclear fusion reactor, a magnificent assemblage of stainless steel vessels, electromagnets and particle accelerator tubes. Once every eight minutes Norman emits a clang, as it transforms 20 million watts of electricity into a cloud of 100 million degrees Celsius plasma and blasts it with beams of protons (the simplest form of hydrogen). They smash together with enough force to fuse into helium—releasing copious amounts of energy in the process. "It's a function of violence," says Binderbauer, 50, with a smile.

TAE, known until last year as Tri Alpha Energy, has raised $600 million, most recently at a valuation of more than $2 billion. Investors include the late Paul Allen's Vulcan Capital, the Rockefeller family's Venrock, and Big Sky Capital, family money of billionaire stock trader Charles Schwab. They're betting that TAE will be able to tame fusion into a source of electricity.

Fission, which powers several hundred nuclear plants, is the splitting of uranium atoms into medium-size atoms to release energy. Fusion, which makes the stars glow, goes the other way, combining small atoms into larger ones to release energy. Fission carries the risk of a meltdown and creates radioactive waste that has to be set aside for 10,000 years. Fusion promises to be meltdown-proof and waste-free.

"With fission it's a chain reaction—once you're in, it's a like a pact with the devil; it's hard to get out," says Binderbauer, an effusive talker who runs TAE from a eucalyptus-lined industrial park southeast of Los Angeles. "With fusion you don't have that. It's tricky to get started and even trickier to keep going."

Tricky—or impossible. Binderbauer likens the process of controlling a ball of plasma to holding a spinning ball of liquid Jell-O in place with rubber bands: "We struggle with a millionth of a second, and the stuff oozes away." A hundred million degrees, moreover, is too cool; TAE aims for 2 billion degrees.

Russian physicists began working on fusion in the 1950s. They thought a commercial

reactor might be ready in 15 years. That's been the forecast ever since. In a corner of the laboratory, Binderbauer keeps a gallery of past fusion prototypes, none of which produced more electricity than it consumed.

But the believers keep coming. "Right now, nuclear technology is the only scalable, base-load, zero-carbon power source," Bill Gates says in a statement. "But it comes with a number of challenges."

Gates is putting money into a Massachusetts Institute of Technology fusion spinoff called Commonwealth Fusion Systems, which hopes to have an energy-positive reactor by 2025. Digital billionaires Peter Thiel and Jeff Bezos are backing yet other fusion schemes. They're all competing with a multinational project in France that is using $20 billion of taxpayer money.

"I understood the limitations of renewables," says Charles Schwab's son Michael, who invested $50,000 in Tri Alpha in 2002 when he was 25 and has participated in every funding round since. "This could solve our energy problems."

What makes fusion safer than fission? The reactor is under vacuum, explains David Hill, director of a fusion test reactor at General Atomics in San Diego. "Any leaks are inward, and a leak would put the fire out." Besides, he says, there's nothing to melt down. "If you turned all the plasma into a solid" and piled it up, the amount "is less than a grain of salt."

Tri Alpha Energy got its start with Norman Rostoker (1925–2014), a Canadian who taught at the University of California, Irvine, and in 1988 won the Maxwell Prize for plasma physics. He and Glenn Seaborg, the Nobelist discoverer of plutonium, saw the technical limitations of the consensus approach to fusion energy, which smashes heavy isotopes of hydrogen together, fusing them into helium while magnetically confined in a donut-shaped vessel called a tokamak. Much of the energy emitted from that reaction comes as high-speed neutrons, which over time corrode the reactor vessel.

Rostoker, with Austrian-born Binderbauer as a postdoctoral student, worked on an alternative plasma-chamber reaction that involves shooting beams of protons (elemental hydrogen) at an isotope of boron. This chemistry produces few neutrons; instead, it spits out positively charged alpha particles that might be able to generate electricity without the steam turbines now seen in nuclear plants. In 1997 they created a stir when Seaborg helped them publicize their breakthroughs in the journal *Science*. But landing government grants to pursue their work was difficult. Too many plasma experts had devoted their careers to the tokamak.

Enter Hollywood. Rostoker met actor Harry Hamlin, the son of a rocket scientist, who, despite being named the sexiest man alive by *People* magazine in 1987, rubbed elbows with plasma physicists at cocktail parties. Hamlin became chairman of Tri Alpha. Then moon-walker Buzz Aldrin signed on. Google cofounder Sergey Brin has taken a tour and has lent his artificial intelligence brain trust to help crunch data. Jeffrey Immelt, the deposed boss of General Electric, is the latest star on the board.

Celebrity brings in dollars, and TAE drinks up a lot of them. The building and equipment in Foothill Ranch, California, cost $150 million (or $250 million including Norman) and need

another $50 million a year to keep humming. Now Binderbauer wants $200 million or so to build the first hydrogen-boron prototype, the last stepping-stone in plasma research before a commercial fusion reactor, operating at much higher temperatures.

Binderbauer fantasizes about the economics. Solar cells can be made at a cost of a dollar per watt of peak-time generation capacity. Maybe TAE could get the price of building a fusion generator down to $1.50 per watt, at which point its electricity would be cheaper than solar because it doesn't go off at night.

But it's going to be a long wait before venture capitalists see a TAE power plant. To amuse them in the meantime, Binderbauer has set up a subsidiary that produces particle accelerators for use in cancer treatment. (The idea is to shoot neutrons at tumors that have taken up boron molecules, causing a pinpoint of intense heat to kill the tumor.) Last year TAE raised $40 million to build the first device, which will soon be shipped off to China. GE is big in medical equipment, and Immelt's connections will help. TAE is going to need connections, dollars and luck to achieve ignition. Two billion degrees? "It sobers you up," Binderbauer says.

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