Fusion

By Trevor Greene

In 1938, a brilliant German scientist named Hans Bethe proved that fusing atoms rather than splitting them, a process called cold fusion, produces the enormous energy emitted by stars. It is the Holy Grail of scientists because it generates cheap, limitless and environmentally clean energy. A British Columbia startup called General Fusion is getting close to developing the world's first fusion power plant. In June 2021, the company announced that it would build and operate its Fusion Demonstration Plant outside of London to prove their concept. The facility will be located on the campus of the UK Atomic Energy Authority [UKAEA], a world leader in fusion energy development and innovation. In February 2022, the UKAEA fusion reactor made a massive breakthrough, producing 11 megawatts of power over five seconds, more than double what was achieved in similar tests back in 1997.

The joke about fusion energy is that it's 30 years away and always will be, but it remains science's Holy Grail because it generates cheap, limitless clean energy. Nuclear fusion occurs when two atoms are squeezed together so tightly that they merge. The process happens naturally in the sun where sunlight is produced from crushing hydrogen into helium. The hunt for the fusion grail started at the dawn of the nuclear age. Atomic bomb inventor J. Robert Oppenheimer, besides being a brilliant nuclear physicist, was also a cultivated scholar and speaker of eight languages. Witnessing the mushroom cloud from the first nuclear bomb test soar over the New Mexico desert at 0530 local time on July 16, 1945, a passage from a sacred Hindu epic flashed through his mind: "I am become Death, the destroyer of worlds." Hans Bethe was also there that day. By October 1949, Oppenheimer's opposition to the development of the hydrogen bomb led to accusations that he was a Communist supporter. In a twist of karmic justice, Hans Bethe was awarded the 1967 Nobel Prize for physics.

Outside of Star Wars fan clubs, very few people are aware of nuclear fusion. The more well-known fission, which splits atoms, is fueled by rare, enriched uranium. The raw materials for nuclear fusion, deuterium and lithium, are available everywhere. Another key difference is waste product disposal; nuclear fission creates waste products that are radioactive for millions of years and cost millions of dollars to dispose of, as opposed to the waste product of fusion, helium, which can be used to blow up millions of balloons. Also, the energy released by fusion is three to four times greater than that released by fission and takes less than a billionth of a second

as massive amounts of energy are released due to the change in mass. In that moment, at the core of the reaction, the density and temperature of the plasma created is nearly three times that at the centre of the Sun. Fusion scientists are effectively attempting to create a star on Earth. For decades, hundreds of the world's top scientists at massive research organisations have burned through millions of dollars experimenting with futuristic lasers and particle beams in their hunt for the elusive fusion formula. But General Fusion is leading the race for the fusion grail using a revolutionary process called magnetised target fusion. The General Fusion reactor looks like a shiny silver lunar module. Inside, hydrogen plasma is injected into a cylinder which is surrounded by a wall of spinning liquid metal. Hundreds of perfectly timed pneumatic hammers strike the cylinder wall with such force that it causes the mixture to compress and merge into helium, which theoretically will cause a fusion burst, setting off temperatures that only occur at the core of the sun. The heat is absorbed by the spinning liquid metal wall, is passed on to an exchanger and used to produce steam that drives a turbine to create electricity. It's a bold, innovative method that hasn't been attempted before.

In September 2001, General Fusion's founder and chief scientist Dr Michel Laberge quit his job designing cutting-edge lasers in Vancouver. Then he actually lived the cliché of garage start-up, doing experiments in a rented garage on Bowen Island. Laberge theorized that the fast microprocessors, advanced materials and space-age control systems that he had used to make his lasers could make a mechanical fusion reactor actually work. Four years later, Laberge re-emerged from the woods with a game-changing idea to revolutionise nuclear fusion. In the academic arena, the General Fusion concept is either cheered or jeered. One unabashed fan is esteemed Berkeley plasma physics professor Dr. T. Kenneth Fowler, who told Canadian Business that he found out about General Fusion when he attended a talk given by Laberge in 2007 at the University of California. "This may be the best idea I've heard. It probably resonated with me because I published a paper that wasn't all that different. (General Fusion) just went for a shorter time scale." One of Canada's leading particle physicists, Erich Vogt, leads the jeer section. Vogt, who helped found TRIUMF, Canada's national laboratory of nuclear and particle physics in Vancouver, refers to General Fusion's lab as "Cloud Cuckooland" and calls the theory "unproven science in the guise of technology development." Well Dr. Vogt, Cuckooland is getting crowded and is awash in venture capital funding. There are over 20 startups chasing the fusion dream

competing with massive, well-funded organizations like the U.S. National Ignition Facility [NIF] in California, which is the size of three football stadiums. It uses 196 high-powered lasers to fire 500 trillion watts in a single shot lasting 20 billionths of a second into a tiny gold cylinder full of hydrogen. The $3.5-billion project was completed five years behind schedule and was almost four times more expensive than originally budgeted. As these bureaucrat-heavy projects lumber along, lean, nimble companies like General Fusion are flexible enough to get results.

Amazon's Jeff Bezos first invested in General Fusion nearly a decade ago and the company has been steadily raising cash since that time, hauling in over US$200 million to date and attracting renowned experts from all over the world. The company's first major milestone came in 2016, when the switch was flipped on the world's largest and most powerful plasma injector. If the London pilot plant reaches a fusion-relevant temperature of more than 100 million degrees Celsius it will prove the concept of magnetised target fusion, a critical step towards commercialization.

It's a long way from toiling alone in a shabby garage on an island to a state-of-the-art research facility funded by billionaires and on to a plant specifically designed to make your earth-shaking dream a reality, but it looks like Dr. Michel Laberge will finally get a chance to create his star on Earth.

