It sounds like science fiction: a giant ball of star-energy suspended inside an enormous chamber, providing the world with clean power.

But sci-fi it’s not. It’s an international science project based in France called ITER (pronounced I-ter), which in Latin means the way or path. Thousands of Americans now work on this futuristic energy experiment, including several Magnet Lab researchers. Engineer Tom Painter is one of them.

“Working on ITER is definitely exciting because it could be a world changer,” says Painter, 47. “I would love to be able to tell my grandchildren that I helped deliver even one small component to this project and made it successful.”

To work on ITER, however, Painter first had to accomplish several big tasks. Perhaps the biggest: He had to start his own company — something he’d always wanted to do — so he could bid on an ITER contract. He also needed a place to house his new business: someplace where he could lay out a half-mile of expensive ITER cable. And to secure such a spot, he would need to relocate some endangered turtles!

He would also need to slash his time at the MagLab — from 40 to 10 hours — in order to get his fledgling company, High Performance Magnetics, off the ground.

“There’s a whole lot of uncertainty in becoming an entrepreneur,” he allows. “My own money was at risk.”

But the opportunity to become his own boss and work on ITER was just too compelling. He took the leap.

**ITER: WHAT IS IT?**

ITER is an experiment to create fusion, a type of nuclear energy, on a scale never before attempted. The genesis for ITER came in 1985, but the chamber where the fusion reactions will take place — called a tokomak — won’t be operational until 2019. And while ITER began as an acronym for International Thermonuclear Experimental Reactor, the words “thermonuclear” and “experimental” aligned side-by-side made many people uneasy; today the ITER community prefers to link its namesake with its Latin meaning.

Fusion is literally star power: Our sun’s warmth and light are the result of fusion reactions. Fusion happens when the nucleus inside a hydrogen atom smashes into the nucleus of another hydrogen atom. This collision causes the two hydrogen nuclei to fuse into heavier helium atoms. When they fuse, they release tremendous energy.

But fusion is not the type of energy produced in today’s nuclear plants. That’s fission. Fission (which in Latin means to split apart) is what happens when an atom’s nucleus is split open. Fission, when done slowly, can generate electricity. When released all at once, it’s an atom bomb.
“Fission and fusion are similar in that both get away from using oil and all the disadvantages of continuing to rely on oil,” Painter says. “The advantage of fusion over fission is that it’s cleaner and it’s safer.”

Nuclear fission plants, such as the Fukushima facility in Japan, have had meltdowns that result in environmental and human disasters.

But fusion is quite a different process.

**BIG TECHNOLOGY, BIG BUCKS**

“I liken fusion to trying to light a match on a cold, wet, windy night in the forest. It’s very hard to get the reaction to start and if anything happens, it just goes out,” Painter says. “And because it’s made from gases and not heavy metals, there’s very little radioactive waste. For example, fission waste lasts for tens of thousands of years. But with fusion, the byproducts — the reactor and whatnot — become benign in about 40 years.”

So why aren’t we using fusion to power our communities now? Well, it’s complicated. To contain and control such power is tremendously complex: The ITER tokomak alone will have more than a million parts. It’s also supremely expensive: The latest estimate puts the cost for ITER’s tokomak and other building at $21 billion. It took seven of the world’s most technologically savvy powers — the U.S., the European Union, Russia, Japan, China, India and South Korea, which in total represent 34 countries and half the world’s population — to join together to create and pay for ITER.

One of the biggest problems with a massive fusion reaction is that there’s no material that can contain it.

“Fusion recreates the power and the conditions inside the sun, and all that energy is very hot: 100 million degrees,” Painter says. “It can’t be contained in any material.”

So how do ITER’s top scientists plan to control such a big, hot mess?

“They’re going to contain it with high magnetic fields. They’re going to levitate it in space and contain it” inside the tokomak (estimated to weigh 23,000 tons when finished — about the weight of three Eiffel Towers).

**COMING IN FOR A LANDING**

This is where researchers such as Painter, who got his master’s degree in engineering from MIT, enter the picture. Painter’s an expert in high magnetic fields and magnets that use superconducting wire. (See “Superwire” on page 14.) And he’s using that expertise to tackle a unique task for ITER. He and his team at High Performance Magnetics intend to put a half-mile-long cable of superconducting wire inside a protective metal tube of conduit.

That’s why on most days, you’ll find him out on a barren stretch of flat, sandy
It’s Superwire!

You can think of a superconductor (and superconducting wire) as a superhero.

Like a superhero, Superwire is much stronger than regular wire. Superwire can transmit far more electricity than regular wire—10 to 100 times more! Yet superconducting wire is much thinner than regular wire: only about as thick as a strand of your hair.

If kept cold enough, Superwire can also transmit electricity with no loss of power. Regular wire loses some current as heat because the atoms in the wire resist the flow of electricity. But current flows through Superwire with no resistance.

There is a catch, though. Just like Superman loses his powers around kryptonite, Superwire loses its power unless it’s kept super cold. To keep Superwire cold, it’s often surrounded (or embedded) with liquid helium. And liquid helium is tricky and expensive to work with.

“Helium is notorious for getting through any little tiny space,” says engineer Tom Painter, an expert in building magnets that use superconductors. “If you have even a teeny tiny crack, it will get through.”

And a helium leak is always bad news. “The whole system is rendered less useful,” Painter says, “or even inoperable.”

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This superconducting wire is not far from where airplanes take off and land. He found the perfect place to set up shop at the old Tallahassee airport, beside the city’s new airport and about six miles from the Mag Lab. “We have two buildings out there that are 800 meters (one-half mile) apart, and between them there’s what looks like a long row of fence posts, but it’s actually steel posts and steel beams.”

After they weld all the tubes of metal conduit together, they will place the one half-mile tube on the beams and pull a cable of superconducting wires through it.

“When we pull the cable through, it’s best to have the tube as flat and straight as possible, so the cable doesn’t snag when we pull it.”

Painter also had to work with the state to relocate some endangered gopher tortoises from the area, before construction could begin. That took several months.

He’s done some traveling as well. He’s gone to the ITER site in south France twice, as well as to an ITER meeting in Japan.

“In Japan, we went to the forge where they actually melt the metal, and we also went to the place where they actually make the tubes. It was pretty exciting.”

EARLY LESSONS PAY OFF

Setting up a super-specialized, high-tech company hasn’t been easy. He credits the Economic Development Council of Tallahassee/Leon County, a private/public partnership, for helping make his business a reality.

“If it weren’t for them, I probably would have never gotten started. They put in one of the initial proposals for us for a planning study when we were just a virtual company.”

But Painter also learned a lot about overcoming obstacles as a kid. He grew up the youngest of eight children; his dad, a steel worker, died before Painter was one. His mom raised the family by herself.

As the baby of the family, “I was spoiled by my mom and tormented by my brothers,” he recalls fondly.

In addition to torment, one of his older brothers also inspired him to become an engineer.

“He went to Penn State extension campus, and he was in the library every night until 11 o’clock, and he got straight A’s. I said, ‘Well, that’s what you’ve got to do.’ And if he could do it, I could do it.”

Today he’s très contente that he did.

“I’d encourage any young people to consider getting into the engineering field, as an opportunity to contribute not only to their own lives but to the world in general.”

When it comes to magnet science and technology, he adds, the best is yet to come.

“I think we’re entering a golden age of magnets and materials here in Tallahassee. ... This is where the future will be born.”