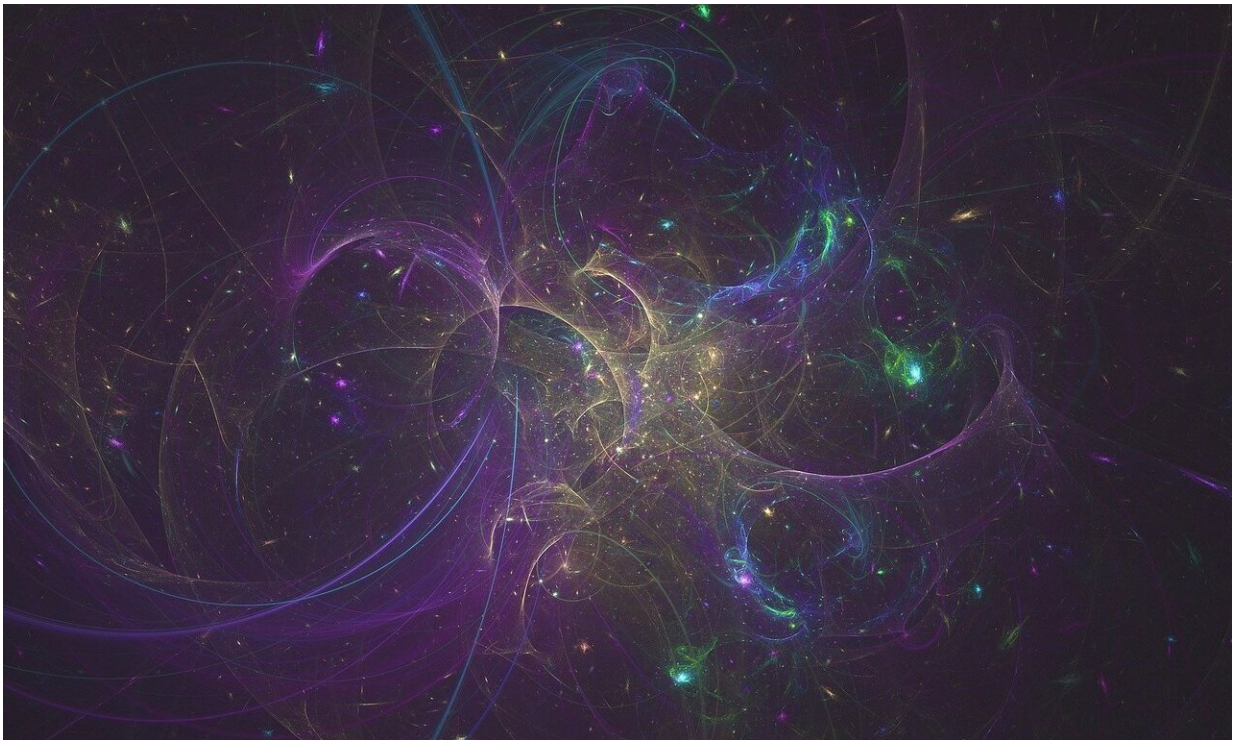


San Diego company hopes to build a nuclear fusion plant. Will the pilot program work?

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For centuries, the world was lit, in the words of a best-selling book, only by fire. Will the not-too-distant future see a world powered largely by fusion?

Global interest, research and investment in nuclear fusion is at an all-

time high and San Diego-based General Atomics has announced a program to design, build and operate a pilot plant aimed at taking a crucial step toward making the long sought-after potential of nuclear fusion a reality—providing a warming planet a [power source](#) that is practically limitless, emissions-free, safe and cost-effective.

"I think fusion-generated electricity will ultimately transform the world with abundant, [clean energy](#). I don't think that's an overstatement," said Wayne Solomon, vice president for Magnetic Fusion Energy at General Atomics. "The question is only how quickly and how much investment we're going to make in it to realize that."

General Atomics has worked on fusion projects for decades and by leveraging the know-how and proprietary technologies the company has developed over the years, the pilot will develop a prototype that produces net electricity gain—meaning its output will exceed its input—that promises to eventually become a full-scale power plant.

"This is really the next step, moving out of the research and development phase of fusion science and putting that knowledge and experience" onto a path to commercial use, said Brian Grierson, director of the Fusion Pilot Plant Hub at General Atomics.

What exactly is nuclear fusion?

Nuclear fusion differs from fission, which is the process used in commercial nuclear power plants such as the now-shuttered San Onofre Nuclear Generating Station. Fission splits the nuclei of atoms to create power while fusion causes hydrogen nuclei to collide and fuse into helium atoms that release incredible amounts of energy—essentially replicating the power of the sun.

Fusion technology was critical in the development of the hydrogen bomb

in the 1950s but a peaceful, commercial application for fusion as an inexhaustible energy source has intrigued scientists ever since.

To fuse hydrogen atoms on earth, they need to be heated to temperatures in the millions of degrees in order to collide and produce a hot gas called plasma.

Nuclear fusion emits no greenhouse gases, leaves behind no long-lived nuclear waste and should a disturbance occur during the fusion process, the plasma cools within seconds and the reaction stops, thereby preventing the risk of a meltdown or accident like the one at Fukushima.

"In terms of the long-term prospects for large scale energy production, I think fusion remains the perfect energy source," Grierson said.

Some specifics of the pilot plant

The first phase of the General Atomics pilot project will center on developing the technologies needed to make the fusion pilot work and then firming up its design.

In the second phase, project officials will concentrate on developing the plant itself—determining where to build it, when to break ground, construction, etc.

The pilot plant will not be some theoretical research project. Upon completion, the plant will be one that "uses real fuel and produces real electricity with generators," Grierson said.

As for when the plant will start operating, no specific date has been announced but General Atomics' Solomon said the company is looking at the mid-2030s.

It's still to be determined where the plant would be located. Solomon said it will probably not be at the company's headquarters near La Jolla or on its Poway campus. Theoretically, the pilot plant could be built anywhere in the country but, Solomon said "all of our folks working here would love to see it being built in Southern California," if costs and regulations prove to be amenable.

General Atomics officials estimate the plant's footprint would resemble that of a conventional electricity-generating station. "It is something certainly much smaller than a large solar farm or a wind farm or anything like that," Grierson said.

The plant is expected to produce a minimum 50 megawatts of electricity.

"We have a sufficient understanding that we can go through this design activity and come up with a facility that looks quite attractive and that can produce net electricity," Solomon said.

"Net electricity" is the crucial term because the key to making fusion practical is to make sure the amount of power going into the plant is exceeded by the amount that's produced. Over the years, fusion power has been generated only for very short periods in laboratory settings.

No price tag has been attached to the pilot plant yet. Solomon said General Atomics has "the resources that we need to execute on our early milestones" and envisions forming partnerships with government and industry to fully fund and complete the project as it moves toward construction.

The federal government has indicated it's getting serious about nuclear fusion.

The recently enacted legislation dubbed the Inflation Reduction Act has

earmarked \$280 million for nuclear fusion projects. The law also provides billions to the Department of Energy's loan program office, some of which could go to fusion proposals.

And in September, the Nuclear Regulatory Commission released a white paper that outlined a licensing and regulatory framework for the fledging fusion industry by the end of 2027.

Lots of experience with fusion

General Atomics has a long history with nuclear fusion research and development.

The company is a key contributor to ITER, a massive, multinational fusion facility under construction in France that is designed to show whether fusion technology can be commercially viable. GA is fabricating and shipping the modules that make up the world's most powerful magnet—called a Central Solenoid—that will be inserted into the heart of the ITER facility.

General Atomics also operates the DIII-D National Fusion Facility, on the behalf of the U.S. Department of Energy. The facility features a magnetic chamber called a tokamak—a doughnut-shaped metal vacuum chamber surrounded by incredibly potent magnets. Fuel consisting of hydrogen isotopes can be converted into plasma by heating the fuel to more than 180 million degrees Fahrenheit.

DIII-D, pronounced "dee-three-dee," is the largest tokamak in the United States.

General Atomic's fusion pilot plant will require building a brand new tokamak, among other infrastructure.

The project will utilize a number of innovations, including:

- the company's proprietary Fusion Synthesis Engine, called FUSE, that enables engineers, physicists and operators to quickly perform a range of studies and continuously optimize the plant's maximum performance, and
- the development of a concept called a "breeding blanket" for tritium (a fusion energy fuel source) which would allow operators to turn fusion power into high grade heat so they can spin turbines and connect them to generators.

"The fusion blanket is a concept that right now is at a relatively low-technology readiness level," Grierson said. "But we have plans for advancing that technology with test stands and demonstrations that we find is a key technology that we need to close the gap before doing a final engineering design."

Fusion fever

General Atomic's [pilot plant](#) comes as increasing numbers of companies are jumping into a burgeoning fusion landscape, with the Fusion Industry Association counting at least 33 companies reporting more than \$4.7 billion in private investments.

Commonwealth Fusions Systems, a private company outside Boston, raised \$1.8 billion from investors such as Bill Gates, George Soros and Google.

Billionaire Jeff Bezos joined other investors last year in raising \$130 million for a startup in Canada called General Fusion to help develop a commercial reactor.

Helion Energy, a fusion company in the Seattle area, last year announced

\$500 million in Series E funding plus an additional \$1.7 billion of commitments tied to specific milestones.

Engineers and scientists for a consortium called Eurofusion made headlines earlier this year when they announced the Joint European Torus, or JET, facility in Oxfordshire, England produced 59 megajoules of heat energy from fusion across a period of five seconds.

"If we can maintain fusion for five seconds, we can do it for five minutes and then five hours as we scale up our operations in future machines," Eurofusion program manager Tony Donne told reporters.

However, 59 megajoules is a very small amount—enough, reports said, to boil about 60 kettles of water—and fusion has its share of skeptics.

"If you're talking about electric power plants from [nuclear fusion](#), yes, I think it's a bridge too far," said Daniel Jassby, who worked in fusion energy research and development for 25 years. "First of all, it proves to be too difficult to get a net electrical power output device. That's probably the most important, most fundamental reason."

Once a principal research physicist at the Princeton Plasma Physics Lab, Jassby thinks concepts proposed so far are vulnerable to "power drains" to such a degree that they would not be practical.

"If your so-called power plant is absorbing 500 megawatts of electricity, it doesn't make much sense to produce 550 megawatts," he said.

Now retired, Jassby said of overcoming the hurdles: "Not in this century; maybe in a hundred years."

Some [environmental groups](#) in Europe have complained about the spending at the ITER project being built in France, saying it diverts

funding that could go to other clean energy projects and research. The most recent cost estimate for ITER came in at \$22 billion, which is more than four times higher than its original projection.

The criticism echoes a long-standing joke in energy circles about fusion—that it's always 30 years away.

"That joke is maybe a little bit unfortunate and unfair but I understand where it comes from," Solomon said. But he remains optimistic.

"We really need new energy sources like fusion," Solomon said. "These pieces have come together in such a way that we are confident that fusion can deliver and that it's worth investing in."

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