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Climate Forward

Can Fusion Solve the Climate Crisis?

Scientists made a huge breakthrough on the road to emissions-free power. Here's what that means, and doesn't mean.

By Henry Fountain
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The news this week that scientists had achieved a breakthrough in fusion technology was hailed as a milestone on the path toward a future of nearly limitless, emissions-free power.

But if you think that means the days of burning fossil fuels for electricity will soon be over, enabling the world to more easily meet the goal of limiting warming this century, you may end up being disappointed.

The breakthrough is a huge step toward a long-held dream, one that has captured the world's collective imagination: The ability to mimic the way the sun generates the energy that sustains life on Earth, and to control that process for the good of humankind.

The achievement, at Lawrence Livermore National Laboratory in California, "will go down in the history books," said Energy Secretary Jennifer M. Granholm at a news conference Tuesday.

A remarkable achievement

As my colleague Ken Chang wrote, scientists working on a mammoth experiment at Livermore, in which lasers are used to fuse two forms of hydrogen into helium, reported that, for the first time, it had released more energy than the lasers put in.

That's a big deal. Scientists around the world have been trying to develop controllable fusion (as opposed to the out-of-control fusion of a hydrogen bomb) for the better part of a century. While there have been many advances, a fundamental stumbling block remained. Fusion requires so much power, with temperatures of millions of degrees needed for it to occur, that none of the experiments produced a net gain of energy.

That hurdle is now out of the way, at least for this kind of laser-instigated fusion. That makes it easier to envision a future of fusion power plants that would produce essentially no planet-warming carbon dioxide or other greenhouse gases. They would also have advantages over current nuclear plants that split, rather than fuse, atoms, because the fuel needed for fusion is more readily available and the radioactive waste produced is far less dangerous and problematic.

… but huge hurdles remain

An experiment like the one at Livermore, in which one tiny pellet was vaporized by 192 laser beams, is one thing, but a power plant that rapidly vaporizes thousands upon thousands of pellets and safely draws off the released energy for conversion into electricity is quite another. That's not to say it can't be done, it will just take time. Lots of time.

The same goes for the other major approach to developing fusion, which uses huge, powerful electromagnets to confine a cloud of hydrogen gas stripped of its electrons, raising temperatures to the point where fusion can occur. This is the so-called tokamak approach (taken from a Russian acronym for the doughnut-like chamber that contains the gas cloud).

In 2017, I visited the largest tokamak project, ITER, in southern France. It's a mind-bogglingly complex machine, a multinational effort being assembled from parts produced in many countries. The project was first envisioned in the 1980s; the hope is that it will produce fusion by the mid-2030s.

But ITER, like the Livermore project, is only an experiment. Even if ITER works, designing and building a plant that captures the energy from a tokamak and converts it to electricity is most likely very far-off.

And the world needs to sharply cut emissions soon. To limit warming to 1.5 degrees Celsius above 19th-century levels, the stricter of two limits that came out of the 2015 Paris climate talks, emissions need to reach nearly zero by 2050.

So even if fusion power plants become a reality, it likely would not happen in time to help stave off the near-term worsening effects of climate change. It's far better, many climate scientists and policymakers say, to focus on currently available renewable energy technologies like solar and wind power to help reach these emissions targets.

When could the power start to flow?

So if fusion isn't a quick climate fix, could it be a more long-term solution to the world's energy needs? Perhaps, but cost may be an issue. The National Ignition Facility at Livermore, where the experiment was conducted, was built for $3.5 billion. ITER's price tag, so far, is more than $20 billion. It's unclear whether the world could afford any fusion power plants that resulted from these two projects.

In recent years there has been a proliferation of private, smaller efforts at developing fusion power, some using alternative approaches. More than 30 companies are working on the technology, about two-thirds of them in the United States, according to the Fusion Industry Association, a trade group. Together they have received nearly $5 billion in private investment.

Of these efforts, Commonwealth Fusion, a company spun off from the Massachusetts Institute of Technology, is among the most advanced. As I wrote in 2020, a series of peer-reviewed studies showed that the approach, a much more compact tokamak than ITER that makes use of advances in electromagnet technology, could work.

The company has raised nearly $2 billion, has begun construction of a test reactor outside of Boston, and is developing plans for a fusion power plant as well.

The Fusion Industry Association says that most of the companies involved in these smaller efforts predict that fusion will provide electricity to the grid sometime in the 2030s. That may be an aspirational, rather than realistic, goal. But if fusion power is to become commercially viable and a clean-energy alternative, perhaps it will be through one or more of these efforts.

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