***With oil, LNG and coal forecasted to be exhausted in about 4o years, life on earth will be severely impacted if these sources of energy are not be replaced, so that Mankind can continue living on this planet.***

***But recently at the National Ignition Facility, a fusion experiment succeeded, with powerful lasers which generated more energy than was used in the experiment. This is the first step in generating nuclear power that theoretically can be used to provide power for Mankind. However, it will take many more experiments to scale up this technology for powering civilization.***

**IO December 5, 2022**, scientists at Lawrence Livermore National Laboratory’s National Ignition Facility made history by successfully producing a [nuclear fusion](https://www.cnn.com/us/live-news/nuclear-fusion-reaction-us-announcement-12-13-22/index.html) reaction resulting in a net energy gain, a breakthrough hailed by US officials as a “landmark achievement” and a “milestone for the future of clean energy.” However, this is just the first step in harnessing nuclear power and replacing tradition energy sources for powering all the energy needs for Mankind.

US Energy Secretary **Jennifer Granholm** noted that the nuclear fusion experiment conducted by US scientists replicated "certain conditions that are only found in the stars and sun." She added that the successful experiment allows us to replicate for the first time certain conditions that are only found in the stars and sun. This milestone moves us one significant step closer to the possibility of zero-carbon abundant fusion energy powering our society.

Leading the nuclear fusion engineering challenge at the Livermore Laboratory is a Chinese American female **Tammy Ma** who has called this effort a "monumental undertaking."

The consensus among several nuclear experts is that a solution to generating sufficient volume of energy to replace the energy needs for future humanity will take a few decades to achieve.

Our nuclear scientists are pretty highly motivated as their project has monumental significance. We need our national leaders to generously fund this effort.

An interesting side note, followers of this breakthrough technical development may have missed that the leaders of this project are all ladies, beginning with Arati Prahaken, the White House Officer for S&T Policy (who is a nuclear scientist), the Secretary of Energy is Jennifer Granholm, the Undersecretary for Nuclear Security and National Nuclear Security Administration (NNSA) is Jill Hruby, Kimberly Budil is the Director of the Lawrence Livermore National Laboratory and Tammy Ma is the leading fusion engineer at the Livermore Laboratory. This is quite a distinction.

There are rumors that the Chinese are conducting similar research. Sounds like a project worthy of joint efforts. Everyone will benefit, if nuclear technology can be harnessed for the benefit of all.

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**SOURCES:**

**The US Department of Energy said Sunday it would announce a "major scientific breakthrough" this week after media reported a federal laboratory had recently achieved a major milestone in nuclear fusion research.**

***The US Is Poised to Reveal a 'Major Scientific Breakthrough' on Nuclear Fusion***

**PHYSICS, *AFP*, 13 December 2022**

The US Department of Energy said Sunday it would announce a "major scientific breakthrough" this week after media reported a federal laboratory had recently achieved a major milestone in nuclear fusion research.

The Financial Times reported Sunday that scientists in the California-based Lawrence Livermore National Laboratory (LLNL) had achieved a "net energy gain" from an experimental fusion reactor.

That would represent the first time that researchers have successfully produced more energy in a fusion reaction – the same type that powers the Sun – than was consumed during the process, a potentially major step in the pursuit of zero-carbon power.

Energy Department and LLNL spokespeople told AFP they could not comment or provide confirmation regarding the FT report, but said US Energy Secretary Jennifer Granholm would "announce a major scientific breakthrough" on Tuesday.

The LLNL spokesperson added that their "analysis is still ongoing".

"We look forward to sharing more on Tuesday when that process is complete," she said.

The fusion reaction that produced a 120 percent net energy gain occurred in the past two weeks, the FT said, citing three people with knowledge of the preliminary results.

The Washington Post later reported two people familiar with the research confirmed the development, with a senior fusion scientist telling the newspaper, "To most of us, this was only a matter of time".

Nuclear fusion is considered by some scientists to be a potential energy of the future, particularly as it produces little waste and no greenhouse gases.

"If this fusion energy breakthrough is true, it could be a game changer for the world," tweeted Ted Lieu, a member of Congress from California.

Fusion differs from fission, the technique currently used in nuclear power plants, by fusing two atomic nuclei instead of splitting one.

The LLNL fusion facility consists of almost 200 lasers the size of three football fields, which bombard a tiny spot with high levels of energy to initiate a fusion reaction.

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**Scientists Achieve Nuclear Fusion Breakthrough With Blast of 192 Lasers**

***The advancement by Lawrence Livermore National Laboratory researchers will be built on to further develop fusion energy research****.*

**By Kenneth Chang, *NYT*, Dec. 13, 2022**

That sparked public excitement as scientists have for decades talked about how fusion, the nuclear reaction that makes stars shine, could provide a future source of bountiful energy.

The result announced on Tuesday is the first fusion reaction in a laboratory setting that actually produced more energy than it took to start the reaction.

“This is such a wonderful example of a possibility realized, a scientific milestone achieved, and a road ahead to the possibilities for clean energy,” Arati Prabhakar, the White House science adviser, said during a news conference on Tuesday morning at the Department of Energy’s headquarters in Washington, D.C. “And even deeper understanding of the scientific principles that are applied here.”

If fusion can be deployed on a large scale, it would offer an energy source devoid of the pollution and greenhouse gases caused by the burning of fossil fuels and the dangerous long-lived radioactive waste created by current nuclear power plants, which use the splitting of uranium to produce energy.

Within the sun and stars, fusion continually combines hydrogen atoms into helium, producing sunlight and warmth that bathes the planets. In experimental reactors and laser labs on Earth, fusion lives up to its reputation as a very clean energy source.

There was always a nagging caveat, however. In all of the efforts by scientists to control the unruly power of fusion, their experiments consumed more energy than the fusion reactions generated.

**That changed at 1:03 a.m. on Dec. 5 when 192 giant lasers at the laboratory’s National Ignition Facility blasted a small cylinder about the size of a pencil eraser that contained a frozen nubbin of hydrogen encased in diamond**.

The laser beams entered at the top and bottom of the cylinder, vaporizing it. That generated an inward onslaught of X-rays that compresses a BB-size fuel pellet of deuterium and tritium, the heavier forms of hydrogen.

In a brief moment lasting less than 100 trillionths of a second, 2.05 megajoules of energy — roughly the equivalent of a pound of TNT — bombarded the hydrogen pellet. Out flowed a flood of neutron particles — the product of fusion — which carried about 3 megajoules of energy, a factor of 1.5 in energy gain.

This crossed the threshold that laser fusion scientists call ignition, the dividing line where the energy generated by fusion equals the energy of the incoming lasers that start the reaction.

You see one diagnostic and you think maybe that’s not real and then you start to see more and more diagnostics rolling in, pointing to the same thing,” said Annie Kritcher, a physicist at Livermore who described reviewing the data after the experiment. “It’s a great feeling.”

The successful experiment finally delivers the ignition goal that was promised when construction of the **National Ignition Facility** (**NIF**) started in 1997. When operations began in 2009, however, the facility hardly generated any fusion at all, an embarrassing disappointment after a $3.5 billion investment from the federal government.

In 2014, Livermore scientists finally reported some success, but the energy produced was minuscule — the equivalent of what a 60-watt light bulb consumes in five minutes. Progress over the next few years was slight and small.

Then, in August last year, the facility produced a much larger burst of energy — 70 percent as much energy as the laser light energy.

In an interview, Mark Herrmann, program director for weapons physics and design at the Livermore, said the researchers then performed a series of experiments to better understand the surprising August success, and they worked to bump up the energy of lasers by almost 10 percent and improve the design of the hydrogen targets.

The first laser shot at 2.05 megajoules was performed in September, and that first try produced 1.2 megajoules of fusion energy. Moreover, analysis showed that the spherical pellet of hydrogen was not squeezed evenly, and some of the hydrogen essentially squirted out the side and did not reach fusion temperatures.

The scientists made some adjustments that they believed would work better.

“The prediction ahead of the shot was that it could go up a factor of two,” Dr. Herrmann said. “In fact, it went up a little more than that.”

**The main purpose of the National Ignition Facility is to conduct experiments to help the United States maintain its nuclear weapons**. That makes the immediate implications for producing energy tentative.

Fusion would be essentially an emissions-free source of power, and it would help reduce the need for power plants burning coal and natural gas, which pump billions of tons of planet-warming carbon dioxide into the atmosphere each year.

But it will take quite a while before fusion becomes available on a widespread, practical scale, if ever.

“Probably decades,” Kimberly S. Budil, the director of Lawrence Livermore, said during the Tuesday news conference. “Not six decades, I don’t think. I think not five decades, which is what we used to say. I think it’s moving into the foreground and probably, with concerted effort and investment, a few decades of research on the underlying technologies could put us in a position to build a power plant.”

ost climate scientists and policymakers say that to achieve that goal of limiting warming to 2 degrees Celsius, or the even more ambitious target of 1.5 degrees Celsius of warming, the world must reach net-zero emissions by 2050.

**IS FUSION THE SOLUTION? What the advance does and doesn’t mean for the climate crisis**.

Fusion efforts to date have primarily used doughnut-shaped reactors known as tokamaks. Within the reactors, hydrogen gas is heated to temperatures hot enough that the electrons are stripped away from the hydrogen nuclei, creating what is known as a plasma — clouds of positively charged nuclei and negatively charged electrons. Magnetic fields trap the plasma within the doughnut shape, and the nuclei fuse together, releasing energy in the form of neutrons flying outward.

The work at NIF takes a different approach, but so far, little work has gone into turning the idea of a laser fusion power plant into reality. **“There are very significant hurdles, not just in the science, but in technology,” Dr. Budil said.**

**NIF is the world’s most powerful laser, but it is a slow and inefficient one, relying on decades-old technology.**

The apparatus, about the size of a sports stadium, is designed to perform basic science experiments, not serve as a prototype for the generation of electricity.

It averages about 10 shots per week. A commercial facility using the laser fusion approach would need much faster lasers, able to shoot at a machine-gun pace, perhaps 10 times a second.

NIF also still consumes far more energy than is produced by the fusion reactions.

Although the latest experiment produced a net energy gain compared to the energy of the 2.05 megajoules in the incoming laser beams, NIF needed to pull 300 megajoules of energy from the electrical grid in order to generate the brief laser pulse.

Other types of lasers are more efficient, but experts say a viable laser fusion power plant would likely require much higher energy gains than the 1.5 observed in this latest fusion shot.

“You’ll need gains of 30 to 100 in order to get more energy for an energy power plant,” Dr. Herrmann said.

**He said Livermore would continue to push NIF fusion experiments to higher fusion output.**

“That’s really what we’re going to be looking at honestly over the next few years,” Dr. Herrmann said. “These experiments show that even a little bit more laser energy can make a big difference.”

Researchers elsewhere are looking at variations of the NIF experiment. Other types of lasers at different wavelengths might heat the hydrogen more efficiently.

Some researchers favor a “direct drive” approach to laser fusion, using the laser light to directly heat the hydrogen. That would get more energy into the hydrogen, but could also create instabilities that thwart the fusion reactions.

In March, the White House held a summit to seek to accelerate commercial fusion efforts.

**“Developing an economically attractive approach to fusion energy is a grand scientific and engineering challenge,” Tammy Ma, who leads an effort at Livermore to study the possibilities. “Without a doubt, it will be a monumental undertaking.”**

Dr. Ma said that a report commissioned by the energy department to provide a framework for laser fusion energy research would come out soon.

“Such a program,” she said, “will inevitably require participation from across the community,” including academia, start-up companies and public utilities in addition to national laboratories like Livermore.

The results announced Tuesday will benefit the scientists working on the nuclear stockpile, the NIF’s primary purpose. By performing these nuclear reactions in a lab at a less destructive scale, scientists aim to replace the data they used to gather from underground nuclear bomb detonations, which the United States stopped in 1992.

The greater fusion output from the facility will produce more data “that allows us to maintain the confidence in our nuclear deterrent without the need for further underground testing,” Dr. Herrmann said. “The output, that 30,000 trillion watts of power, creates very extreme environments in itself” that more closely resemble an exploding nuclear weapon.

**Riccardo Betti, chief scientist of the Laboratory for Laser Energetics at the University of Rochester, who was not involved with this particular Livermore experiment, said, “This is the goal, to demonstrate that one can ignite a thermonuclear fuel in the laboratory for the first time.”**

**“And this was done,” he added. “So this is a great result.”**

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**What you need to know about today's nuclear fusion announcement — and what comes next**

**From CNN's Ella Nilsen and René Marsh**



**NIF Target Area operators inspect a final optics assembly during routine maintenance at Lawrence Livermore National Laboratory’s National Ignition Facility. (Jason Laurea/Lawrence Livermore National Laboratory)**

**Scientists at Lawrence Livermore National Laboratory’s National Ignition Facility have made history by successfully producing a**[**nuclear fusion**](https://www.cnn.com/us/live-news/nuclear-fusion-reaction-us-announcement-12-13-22/index.html)**reaction resulting in a net energy gain, a breakthrough hailed by US officials as a “landmark achievement” and a “milestone for the future of clean energy.”**

Here are [key things to know](https://www.cnn.com/2022/12/12/us/common-questions-nuclear-fusion-climate/index.html) about today's announcement — and possible next steps:

**What is nuclear fusion and why does it matter?** Nuclear fusion is a man-made process that replicates the same energy that powers the sun.**Nuclear fusion happens when two or more atoms are fused into one larger one, a process that generates a massive amount of energy as heat.**

***Scientists around the world have been studying nuclear fusion for decades, hoping to recreate it with a new source that provides limitless, carbon-free energy – without the nuclear waste created by current nuclear reactors.*** Fusion projects mainly use the elements deuterium and tritium – both of which are isotopes of hydrogen.

***The deuterium from a glass of water, with a little tritium added, could power a house for a year. Tritium is rarer and more challenging to obtain, although it can be synthetically made***.

***“Unlike coal, you only need a small amount of hydrogen, and it is the most abundant thing found in the universe,” Julio Friedmann, chief scientist at Carbon Direct and a former chief energy technologist at Lawrence Livermore, told CNN. “Hydrogen is found in water so the stuff that generates this energy is wildly unlimited and it is clean.”***

**Why was today's announcement significant?** This is the first time scientists have ever successfully produced this, instead of breaking even as past experiments have done.

***While there’s many more steps until this can be commercially viable, it’s essential for scientists to show that they can create more energy than they started with. Otherwise, it doesn’t make much sense for it to be developed.***

“This is very important because from an energy perspective, it can’t be an energy source if you’re not getting out more energy than you’re putting in,” Friedmann told CNN. “Prior breakthroughs have been important but it’s not the same thing as generating energy that could one day be used on a larger scale.”

**What are the next steps?** **Scientists and experts now need to figure out how to produce much more energy from nuclear fusion on a much larger scale.**

**At the same time, they need to figure out how to eventually reduce the cost of nuclear fusion so that it can be used commercially.**

**Scientists will also need harvest the energy produced by fusion and transfer it to the power grid as electricity. It will take years – and possibly decades – before fusion can be able to produce unlimited amounts of clean energy, and scientists are on a race against the clock to fight climate change.**

12:35 p.m. ET, December 13, 2022

**Energy secretary says nuclear fusion breakthrough could help achieve zero-carbon emission power**

**Secretary of Energy Jennifer Granholm** said the history-making accomplishment in nuclear fusion that [was announced on Tuesday](https://www.cnn.com/2022/12/13/us/energy-officials-announce-nuclear-fusion-climate-scn/index.html) "essentially unlocked a whole new source of clean energy."

For the first time, US scientists produced more energy from fusion than the laser energy they used to power the experiment, resulting in a ["net energy gain."](https://www.cnn.com/2022/12/12/us/common-questions-nuclear-fusion-climate/index.html)

"More energy came out of these reactions than put into it," she explained about the breakthrough.

"If we could get this scale, this will be an amazing endeavor of ... achieving the goal of zero-carbon emission power," she said on CNN.

Granholm said the private sector is "very interested" in this development as well, and **she referenced President Joe Biden's 10-year goal of getting to a commercial fusion reactor.**

**"We have a goal of getting to net-zero energy by 2050, so that would be within that time frame.** But now that this breakthrough has happened, the scientists can go to work on improving the process," she said.

As the climate crisis continues, Granholm also said that the onus is not just on the United States or on a specific type of clean energy.

**"We have a lot more work to make sure it's not just the United States, it's other countries as well**. So our example, both in the the fusion example — as well as in all of these other of the technologies and policies — are being looked at very seriously by other countries who also want to do their part," she said.

10:45 a.m. ET, December 13, 2022

**Laboratory director says it will take "probably decades" before nuclear fusion energy is commercialized**

**Kim Budil, director of the Lawrence Livermore National Laboratory, said there are still "significant hurdles" to overcome with the nuclear fusion technology before commercialization will be possible**.

She pointed out [that today's announcement](https://www.cnn.com/2022/12/12/us/common-questions-nuclear-fusion-climate/index.html)is marking one fusion ignition event, and that to "realize commercial fusion energy" you will need to "do many, many things" — including producing "many many fusion ignition events per minute" while having a "robust system of drivers to enable that."

**On the timeline for commercialization, Budil said, “probably decades; not six decades, not five decades – which is what we used to say."**

"I think it’s moving into the foreground — and probably with concerted effort and investment, a few decades of research on the underlying technologies could put us in a position to build a power plant," she added.

A team of scientists at Budil's laboratory in California made history on Dec. 5 after successfully producing a [nuclear fusion](https://www.cnn.com/us/live-news/nuclear-fusion-reaction-us-announcement-12-13-22/index.html) reaction resulting in a net energy gain, according to US Department of Energy officials.

11:00 a.m. ET, December 13, 2022

**There will be further "breakthroughs" and "setbacks" going forward, nuclear security official says**

**Jill Hruby, under secretary for the Nuclear Security and National Nuclear Security Administration (NNSA) administrator, said that "going forward," this work will have further "breakthroughs" and "setbacks."**

**Hruby added that their work is focused on "promoting national security" while "pushing towards ... a clean energy future."**

She said that today's "unprecedented' announcement confirms what she and others have been saying for decades, which is that there isn't a "more dedicated or talented group of scientists" working today.

10:43 a.m. ET, December 13, 2022

**Biden science adviser says generations of scientists "never lost sight of this goal" with nuclear fusion**



**Arati Prabhakar delivers remarks during a press conference on Tuesday. (US Department of Energy)**

**Arati Prabhakar, director of the White House Office of Science and Technology Policy and science adviser to President Joe Biden, said**[**the nuclear fusion breakthrough**](https://www.cnn.com/2022/12/12/us/common-questions-nuclear-fusion-climate/index.html)**announced on Tuesday is a "scientific milestone" and also an "engineering marvel."**

Prabhakar spoke about how as a 19-year-old student, she spent three months at Lawrence Livermore National Laboratory in California working on its nuclear fusion project.

"They never lost sight of this goal," Prabhakar said.

Prabhakar reflected on the generations of scientists who got to this point with nuclear fusion.

“It took not just one generation but generations of people pursuing this goal. It's a scientific milestone. ... **It’s also an engineering marvel beyond belief,” she said.**

“It’s a century since we figured out it was fusion that was going on in our sun and all the other stars. And in that century, it took so many different kinds of advances that ultimately came together to the point that we could replicate that fusion activity in a laboratory,” she added.

10:22 a.m. ET, December 13, 2022

**Why a net gain in energy matters**

From CNN’s Ella Nilsen

**We are still a very long way from having fusion power the electric grid, never mind one power plant itself. The US project, while groundbreaking, only produced enough energy to boil about 2.5 gallons of water, Tony Roulstone, a fusion expert from the University of Cambridge’s Department of Engineering, told CNN.**

That may not seem like much, but the experiment is still hugely significant because scientists demonstrated that they can actually create more energy than they started with. While there’s many more steps until this can be commercially viable, that is a major hurdle to cross with nuclear fusion, experts say.

“This is very important because from an energy perspective, it can’t be an energy source if you’re not getting out more energy than you’re putting in,” Julio Friedmann, chief scientist at Carbon Direct and a former chief energy technologist at Lawrence Livermore, told CNN on Monday. “Prior breakthroughs have been important but it’s not the same thing as generating energy that could one day be used on a larger scale.”

Past fusion experiments including one in the United Kingdom have generated more energy but have not had nearly as big of an energy gain. For instance, earlier this year, UK scientists generated a record-setting 59 megajoules of energy – about 20 times as the US-based project. Even so, the UK project only showed an energy gain of less than one megajoule.

**There’s still many years and a long way to go to make the project commercially viable**. **Neither** the US or UK-based projects “have the hardware and steps in place to convert fusion neutrons to electricity,” **Anne White, head of MIT’s Department of Nuclear Science and Engineering**, told CNN.

But Roulstone pointed out that big ambitious nuclear energy projects have to start somewhere: In 1942, scientists in Chicago ran the first fission nuclear reactor for just 5 minutes in its first run; 15 years later, the first US-based nuclear power plant went online in Pennsylvania.

11:49 a.m. ET, December 13, 2022

**US energy secretary: Scientists replicated conditions "only found in the stars and sun"**



**US Secretary of Energy Jennifer Granholm speaks during a press conference on Tuesday. (US Department of Energy)**

**US Energy Secretary Jennifer Granholm** said Tuesday morning that the nuclear fusion experiment conducted by US scientists replicated "certain conditions that are only found in the stars and sun."

"Ignition allows us to replicate for the first time certain conditions that are only found in the stars and sun. This milestone moves us one significant step closer to the possibility of zero-carbon abundant fusion energy powering our society," she said.

**Granholm continued: “This is what it looks like for America to lead, and we’re just getting started.”**

**“If we can advance fusion energy, we could use it to produce clean electricity, transportation fuels, power, heavy industry and so much more.”**