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Harnessing the Sun: The Triumph of American Innovation

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TOPLINE POINTS

- ★ Department of Energy's Lawrence Livermore National Laboratory National Ignition Facility based in California announced "a major breakthrough" in the long quest to harness the power of the sun through nuclear fusion reaction.
- ★ The announcement marked a generational breakthrough as scientists achieved a net energy output, producing 2.5 megajoules (MJ) of energy compared to the 2.1 MJ required to conduct the fusion reaction.
- ★ To date, immense excitement within the private sector has generated more than $4.7 billion in new capital investment into nuclear fusion, serving as a watershed for innovation and development of the near-limitless energy source.

In December 1953, President Dwight D. Eisenhower presented his vision for the future of humanity at the annual summit of the International Atomic Energy Agency. Known as "Atoms for Peace," President Eisenhower outlined a future in which the power of nuclear warheads could be transformed into a tool of prosperity and opportunity capable of illuminating new vistas for the developed and developing world alike, stating "this greatest of destructive forces can be developed into a great boon, for the benefit of all mankind."

President Eisenhower's vision, while focused mainly on the future advancements in nuclear fission, applies even more so to nuclear fusion. The vision spurred a global paradigm shift in how nuclear capabilities were viewed. Not only would the world embrace the adoption of civil nuclear power generation in the form of nuclear fission, but nuclear fusion would take center stage following the Second United Nations International Conference on the Peaceful Uses of Atomic Energy in 1958.

THE BASICS OF NUCLEAR FUSION

Nuclear fusion is the process by which atoms collide and fuse at extreme temperatures and pressures, releasing large amounts of energy. More specifically, the process requires using hydrogen isotopes, principally deuterium and tritium, to trigger the "ignition" of the nuclear fusion reaction, the byproduct of which is helium. There are two primary means of achieving a fusion reaction. First, scientists have developed the inertial confinement method—the process by which conditions for a fusion reaction are triggered by the concentration of lasers on a fuel capsule. Second, magnetic confinement uses super magnets to generate the pressure and heat within the fuel capsule necessary to ignite a fusion reaction.

Furthermore, unlike nuclear fission, fusion does not carry any negative aspects often feared by anti-nuclear activists, such as nuclear accidents or radioactive waste. For instance, the disasters of Chornobyl and Three Mile Island are impossible, given that fusion reactions cannot trigger meltdowns. The issue is not that a reaction can be contained but whether it can be sustained.

There are three primary considerations in the development of a commercially viable fusion reactor:

1. The reaction must create a net output of energy.
2. The design must mitigate the potential for degradation of the containment walls (i.e., system longevity).
3. The design must effectively and efficiently convert the energy produced into a useful output (i.e., electricity).

The primary barriers to overcoming these three obstacles have primarily been funding, proper management and strategic planning, and the availability of sufficiently advanced technology. However, at Lawrence Livermore National Laboratories (LLNL) National Ignition Facility, a recent breakthrough has demonstrated the leading technological capabilities of American innovation in overcoming at least one of these barriers.

U.S. LANDMARK MILESTONES IN NUCLEAR FUSION

Over half a century after President Eisenhower's speech, nuclear fusion remains elusive beyond laboratory-scale operations, and its viability has repeatedly been delayed to 20–30 years on the horizon. Instead, fusion has been confined to the world's leading laboratories, often requiring international collaboration to drive technological breakthroughs, given the immense costs and difficulties of achieving a self-sustaining nuclear fusion reaction.

LLNL's National Ignition Facility utilizes the inertial confinement approach, in which lasers are directed at a contained fuel capsule, which in turn heats the fuel capsule, creating a super-hot plasma that triggers an ignition and a self-sustaining fusion reaction. Last year, LLNL attempted to demonstrate this technology but was only marginally successful. The demonstration yielded only 70 percent of the energy input, producing 1.35 megajoules (MJ) of fusion energy compared to 1.95 MJ of energy fired in the form of lasers at the fuel capsule.

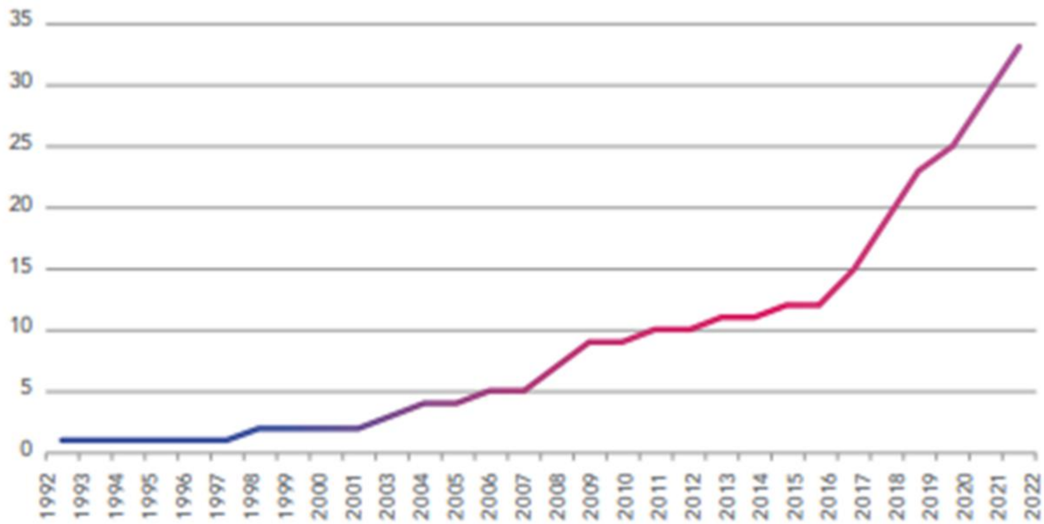
This week, the Department of Energy and the National Nuclear Security Administration announced a generational advancement in the realization of nuclear fusion. LLNL's National Ignition Facility achieved a net energy production in the latest demonstration of its inertial containment design. The demonstration yielded 2.5 MJ compared to the 2.1 MJ fired at the fuel capsule. To put this in perspective, 2.5 MJ is equivalent to 0.7 kilowatt hours—the standard unit of measurement for powering appliances. This means that the output of the LLNL National Ignition Facility's experiment has the capacity to power a 100-watt lightbulb for 7 hours when not accounting for the lost energy input.

Commercial-scale demonstration and deployment of nuclear fusion technology is still a distant reality, and subsequent demonstrations must show that scientists can consistently replicate the events and increasingly scale the demonstration to more practical application levels. However, the timescale is tightening significantly, with many experts hedging towards notable demonstration landmarks within the present decade.

THE VALUE OF PRIVATE SECTOR INNOVATION

A breakthrough in nuclear fusion has long been seen as the "holy grail" of near-limitless clean energy, and the private sector wants in on the action. In the Fusion Industry Association's 2022 survey, fusion companies have secured over $2.8 billion in new private investment since last year, declaring over $4.7 billion of private funding to date, to go along with an additional $117 million in grants and other funding from governments, more than doubling the industry's entire historic investment in a single year. Historically, large publicly funded laboratories would have done this type of research investment. Still, as seen below, in recent years, investment has also flooded into private companies promising to deliver fusion power in the 2030s, not the federal government.

TOTAL NUMBER OF PRIVATE FUSION COMPANIES BY YEAR



Source: Fusion Industry Association's 2022 survey

This is a giant milestone for the advancement of humanity, an incredible American innovation, and a great accomplishment for physics. While we are still far from commercial usage to power our electric grids, this breakthrough has the potential to power vehicles on the high seas and the skies, establish bases on the lunar surface and enable starships to traverse the galaxy—with hydrogen as the most abundant elemental resource in the known universe. Fusion could one day be the go-to fuel for piloting the dreams of humanity as a multi-planetary species. In a world of political polarization and dysfunction, we can all unify toward the advancement and promise of nuclear fusion and, with its success, hope for the longevity of humanity and energy abundance for all. Such an abundance of energy could ring in an era of unprecedented human prosperity.

While we eagerly await the continued innovations of American scientists that inspire generations of pioneering dreamers, the announcement of net energy gain at the LNLL National Ignition Facility brings America one step closer to achieving a new paradigm of energy independence and a new means of energy abundance. Through federal support of early-stage research and development and the continued collaboration with America's world-class private industrial base, our Nation may soon have another tool to revolutionize global prosperity, eradicate energy poverty, and brings the dreams of President Eisenhower closer to reality. If we maintain the course, the question is now definitively not a matter of "if" the world will achieve nuclear fusion but "when."