

Fusion Energy – A Reasonable Starting Point?

By John Benson

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1. Introduction

I have tracked electricity generation facilities of all types, but mainly focus on what I call renewables. My definition of this category includes all types of nuclear generators, including fission and fusion. The last type is just now starting to emerge, so my posts are not very frequent. My last paper from last August on this subject is summarized and linked below.

Hometown Fusion: *Your author has lived in Livermore, California most of his adult life. For those of you that really don't know where this is -- Livermore is on the eastern side of the central SF Bay Area.*

Livermore is really, really important to the second word this is paper's title. I pointed this out in an earlier post about Lawrence Livermore National Laboratory (LLNL) National Ignition Facility (NIF) summarized and linked in this post.

<https://www.energycentral.com/nuclear/post/hometown-fusion-cYlhYnEpZ22h9Pn>

Surprisingly, my main asset in keeping up with LLNL is my hometown newspaper, The Independent, and they recently published an article on a partnership between LLNL and a private fusion energy development firm covered in Section 2. This partnership plans to develop a commercial power plant based on NIF's basic design. Also, I have been working on another Fusion post, and I decided to add it to this paper as Section 3.

2. Inertia Enterprises Signs Public-Private Partnership with LLNL

Livermore, CA (April 14, 2026) — Inertia Enterprises, the commercial fusion energy company, today announced a landmark strategic partnership with Lawrence Livermore National Laboratory (LLNL), establishing one of the largest private sector-led partnerships in the history of the U.S. national lab system.¹

On the heels of its \$450 million funding round, the collaboration with LLNL expands on the robust research and development capabilities and strong capital position Inertia has established and accelerates the company's path towards commercializing fusion energy. To date, LLNL is home to the only facility in the world to show fusion net energy gain.

Inertia and LLNL have signed two Strategic Partnership Projects (SPPs) and a new Cooperative Research and Development Agreement (CRADA), mechanisms that allow private companies to collaborate with national laboratories for research and development. The partnership also includes a licensing agreement for a broad portfolio of nearly 200 patents covering inertial fusion technology developed at LLNL, including exclusive rights to some foundational inventions.

"Decades of public investment in fusion science have created a foundation that only America's national labs could have built. Inertia exists to take that foundation and do what the private sector does best: build at scale and deliver commercial impact," said Jeff Lawson, CEO and co-founder of Inertia. "This partnership with LLNL ensures we're doing that with the full weight of their scientific expertise behind us."

¹ <https://inertia.com/press/inertia-llnl-partnership/>

This expansive partnership is designed to address specific challenges on the path from proven physics to a commercial power plant and marks a monumental step in bridging public and private sector fusion innovation in the United States.

“We are committed to ensuring that the 60 years of public investment, fusion leadership, and scientific breakthroughs achieved here don’t stay in the laboratory. This agreement, along with other public-private partnerships, is how we accelerate that effort,” said Kim Budil, director of LLNL. “This partnership positions LLNL’s world-leading expertise in inertial fusion science, laser technology, physics design, and target fabrication to directly inform the industrial-scale development that commercial fusion demands.”

2.1. Commercial Fusion R&D with Strategic Collaboration

Inertia’s CRADA agreement with LLNL covers the R&D and prototyping of advanced optical materials and semiconductor laser diodes, the development of new manufacturing techniques for high-cost or long-lead components, and design options and experimental validation for a potential beamline architecture to drive Inertia’s planned high-power laser system.

Through its two SPPs with LLNL, Inertia is scaling the performance and production of the fusion fuel targets that are at the heart of the breakthrough demonstrated at the National Ignition Facility (NIF). Under this contract, LLNL staff will apply the same ICF design codes used to achieve ignition to help Inertia design its high-gain fusion target with greater confidence. A large team of LLNL scientists working with Inertia’s team of experts are both developing the target physics design as well as the techniques for rapid target manufacturing capable of meeting the design specifications necessary for grid-scale fusion power plant operation.

2.2. Scientific Leadership and Energy Security

The combination of the two SPPs and CRADA represents one of the most significant private sector-led agreements with a Department of Energy (DOE) national laboratory for a single collaborative program. This partnership aligns with the DOE’s commitment to fusion energy development, including the strategic goals of the Office of Fusion and the foundational science and facilities work advanced by the Fusion Energy Sciences program. Together, these efforts are establishing a new model for translating U.S. scientific leadership into real commercial and strategic advantage.

“Fusion is one of the greatest scientific and technological challenges of our time, and it is one we simply cannot afford to lose. What makes this moment different is that we are no longer pursuing it in isolation,” said Jean Paul Allain, Director of the DOE Office of Fusion. “Through partnerships like this one, we are bringing together the full strength of our National Labs, private industry, and the broader innovation ecosystems to move from breakthrough to deployment.”

“These agreements catalyze progress toward building the world’s first fusion power plant by combining unique expertise and resources across government and industry,” said Mike Dunne, co-founder and Chief Technology Officer of Inertia. “Our work with LLNL speeds up timelines for the multiple innovations vital for commercial fusion energy, bolstering Inertia’s work with other industry and research partners as we develop the processes and supply chains that future fusion power plants will depend on.”

An Outside Business Agreement (OBA) enabled by the 2022 CHIPS and Science Act allows Dr. Andrea “Annie” Kritcher to continue her national security research activities at LLNL while co-founding Inertia to commercialize the historic breakthroughs and technological innovations in fusion science she’s pioneered over her decades-long research career.

“After more than two decades at LLNL working on inertial fusion and high-energy-density physics, designing the first burning, ignited, and net energy gain fusion plasmas and serving as lead for integrated modeling in the Inertial Confinement Fusion Program, I’ve always asserted that realizing this at scale requires a deep partnership with the lab to fully leverage the capability and experience,” said Dr. Kritcher, co-founder and Chief Scientist of Inertia. “Ignition at LLNL showed this approach to fusion works. At Inertia, we now get to build on that foundation and push it to industrial scale. There’s no better team positioned to take this on than the Inertia team, working closely together with the LLNL teams through these robust partnerships, enabling moving quickly from day one.”

2.3. Dr. Kritcher

Author’s comment: Dr. Andrea Kritcher is clearly a key facilitator in developing the partnership between Inertia Enterprises and LLNL. Thus, I thought it would be worth devoting a few more pixels to this amazing scientist.

Andrea Lynn “Annie” Kritcher is an American nuclear engineer and physicist who works at the Lawrence Livermore National Laboratory. She was responsible for the development of Hybrid-E, a capsule that enables inertial confinement fusion. She was elected Fellow of the American Physical Society in 2022.²

She was named to Time 100 for her role as leader and designer for the December 5 test in 2022 which achieved fusion ignition (net energy gain) for the first time.

Dr. Kritcher studied nuclear engineering at the University of Michigan. She moved to the University of California, Berkeley for graduate studies, where she earned a master’s degree and doctorate in nuclear engineering. She spent summer 2004 at the Lawrence Livermore National Laboratory on an internship. Her first project involved analyzing data for the electron beam ion trap. Her doctoral research considered Thomson scattering from shocked compressed matter. She became a postdoctoral researcher at the Lawrence Livermore National Laboratory in 2009. Her postdoctoral research explored using X-rays to measure the properties of warm and hot dense matter (plasma), and measuring how nuclei interact with dense plasma. She made use of the LLNL Jupiter laser and the OMEGA laser at the University of Rochester.

Kritcher was made a permanent member of staff in the Weapons and Complex Integration’s Design Physics Division of LLNL in 2012.

Kritcher works in nuclear engineering, with a particular focus on inertial confinement fusion, which looks to emulate the nuclear processes that take place in the sun by compressing and heating capsules full of thermonuclear fuel. High energy beams (photons or electrons) bombard the outer layer of the capsule, which explodes outward and generates an opposing compression-force that accelerates the remainder of the capsule toward the center. The explosion creates a shockwave that travels through the fuel target, resulting in sufficient heat and compression for the fusion to begin.

² https://en.wikipedia.org/wiki/Andrea_Kritcher

These capsules contain heavy isotopes of hydrogen (typically deuterium and tritium). Kritcher designed Hybrid-E, a target capsule that includes a high-density carbon capsule and a deuterium-tritium fill tube. The capsule is encased in a hohlraum that converts the incident laser light into x-rays. Kritcher said that it was challenging to design the hohlraum such that it generated a symmetric implosion of the capsule. This involved confining the size of the entrance holes to enhance the energy that is coupled into the system, and a structure that can systematically adjust the wavelength of each beam to balance the X-ray energy required to drive the capsule to implode. The Hybrid-E capsule enabled inertial confinement fusion able to produce more than a megajoule (0.28 kwh) of fusion energy. Hybrid-E enabled the first time that it was possible to generate a burning plasma state that emits more energy than the energy required to initiate the fusion.

Dr. Kritcher's citation when she was elected Fellow of the American Physical Society read, "...for leadership in integrated hohlraum design physics leading to the creation of the first laboratory burning and igniting fusion plasma."

Kritcher went on to study the behavior of ions in inertial confinement fusion, showing that the energy of neutrons produced from a deuterium–tritium plasma recorded experimentally was higher than could be predicted from the hydrodynamics-informed algorithms that simulate inertial confinement implosions.

Kritcher was the designer of the December 5, 2022 experiment that achieved fusion breakeven at the National Ignition Facility.

3. Commonwealth Fusion Systems

A U.S.-based fusion energy company has become the first such firm to apply to join a major power grid operator. Massachusetts-based Commonwealth Fusion Systems (CFS) on April 28 said it has submitted an application to connect its ARC power plant to PJM Interconnection, the nation's largest wholesale electricity market.³

CFS on Tuesday said the application marks the first time a fusion power plant developer has requested an interconnection with a power grid operator. PJM serves more than 65 million customers across 13 states and the District of Columbia. CFS, which has raised almost \$3 billion in capital since it was founded in 2018, said it is on track to deliver electricity from fusion energy to the grid in the early 2030s. The power would be generated from the company's planned 400-MW Fall Line Fusion Power Station (Figures below on pages 5 & 6) in Chesterfield County, Virginia.

"Our commitment to delivering the benefits of fusion, and enabling a future with abundant, secure energy, means that we're not just proving fusion physics works—we're showing exactly how fusion power plant watts get from our machine to the customer, working with the grid and a utility," said Bob Mumgaard, co-founder and CEO of CFS. "By becoming the first fusion energy developer to enter a major grid operator's interconnection queue, we're demonstrating that when you're serious about building a power plant in the early 2030s, you act now. This is execution."

³ Darrell Proctor, Power Magazine, "Fusion Energy Group Seeks PJM Connection for First Commercial Power Plant," April 28, 2026, <https://www.powermag.com/fusion-energy-group-seeks-pjm-connection-for-first-commercial-power-plant/>



Commonwealth Fusion Systems (CFS) plans to begin operating the Fall Line Fusion Power Station, home of the company's first ARC fusion power plant, in the early 2030s. This illustration shows a ground-level view of the facility in Chesterfield County, Virginia. Source: Commonwealth Fusion Systems

CFS on Tuesday said the power plant's name, also announced today—it previously had been known simply as ARC, for affordable, robust, compact—references the geological boundary where Virginia's elevated Piedmont region drops down to the Tidewater coastal plain (Fall Line Fusion Power Station). The location creates rapids on the James River. CFS said the site historically has been where "Virginians built mills at the Fall Line to harness the power of falling water ... today, CFS will harness a different energy source: the clean, safe, secure power of fusion."

CFS said that as part of the application submission procedure, the company will work through PJM's "diligent stress-test process to demonstrate that it can reliably help to meet the region's surging energy demands." The company said the plant is being eyed as a resource to meet the increasing energy demands of artificial intelligence-driven data centers in the region, which is part of Virginia's so-called "Data Center Alley." The area is known for its concentration of data centers, and energy analysts have said the region has the highest forecasted power load growth in the U.S. CFS said that by getting into the PJM queue now, the company "will ensure that it will be able to connect to the grid upon completion of the power plant's construction."

Rick Needham, chief commercial officer for CFS, told POWER the company is confident in its timeline for a commercial power plant. "We're quite confident, based on our steady track record of execution since our founding. Over and over, we meet long-term milestones, like securing our supply of high-temperature superconducting [HTS] tape, delivering our first prototype magnet, building a factory, and taking delivery of long-lead equipment like large pieces for SPARC⁴ as well as power, heating, and cooling systems."

Needham added, "And the big milestones build on each other. We first showed we could build a super strong HTS magnet when that was a big question; we then went on to build our SPARC plant that will show how those magnets can make a high-performing fusion machine; and then we will build the first grid-scale fusion power plant based on the prototype SPARC."

⁴ The acronym SPARC stands for "Smallest Possible ARC", where ARC refers to "affordable, robust, compact".

“Each of these milestones opens up the door to the next critical milestone,” said Needham. “They’ve been important proof points on the way to commercial fusion power for our investors and all of our other stakeholders. So, as we get close to completing SPARC and then running it, we’re now also turning our focus to commercialization with the design and development of our first ARC power plant.”

Mumgaard,⁵ subject of a POWER Interview in 2020, and also a guest on the POWER Podcast that year, recently was appointed by President Trump as one of the first members of the President’s Council of Advisors on Science and Technology. He told Reuters in a recent interview that his company intends to build multiple fusion units, adding “The goal will be to get going with the one in Virginia, and if capital is available, if the markets are right, start the next one shortly thereafter. And so that way you’ll get the learning rates, and you can learn as you go, from one to the next, to the next, and eventually you get to the point where you feel like you’ve got it really sorted out. The technology shown to work, the supply chain there, the design refined to the point where you would want to build them in parallel, and that would be the bigger scaling phase.”

Said Needham, “We’ve advanced our efforts to commercialize our ARC fusion power plant in parallel with work on our SPARC⁴ fusion demonstration machine. We’ve chosen a location, brought Dominion Energy on board as a utility partner, and signed up Google and Italian energy company Eni as customers. And finally ... we’ve built a world-class team with expertise across all the necessary functions to not only understand fusion but then actually deliver it.

“This is a team delivering SPARC, one of the most important construction projects in the world, while at the same time building and running the most advanced HTS magnet manufacturing facility in the world and engaging with all the stakeholders, partners, and customers needed to deliver fusion power on a time scale that matters,” said Needham.

3.1. Different Approach to a Tokamak

CFS was featured in a POWER Special Report in February of this year that looked at some of the leading companies in the fusion energy space. The company has said it is taking a different approach to the tokamak design; industry experts have said that years of research worldwide have established the tokamak-based configuration as the highest-performing approach to fusion. Instead of building a large tokamak, CFS is “using revolutionary high-temperature superconducting [HTS] magnets developed in collaboration with MIT [Massachusetts Institute of Technology] to build smaller and lower-cost tokamak fusion systems (Figure below).”

This illustration shows Commonwealth Fusion Systems’ ARC⁴ fusion power plant design. This donut-shaped machine, called a tokamak, uses powerful magnets to confine and control a highly energetic cloud of hydrogen nuclei called a plasma. When heated to about 100 million degrees Celsius, these particles fuse, releasing tremendous amounts of energy that’s captured as heat and converted to electrical power. Source: Commonwealth Fusion Systems



⁵ Bob Mumgaard, co-founder and CEO of Commonwealth Fusion Systems.

CFS has made several milestone announcements in the past few years. The company in January said it would develop a digital twin of its SPARC⁴ fusion machine along with chipmaker NVIDIA and energy technology group Siemens. The group in October of last year reached a milestone with delivery of the first half of the vacuum vessel at the heart of SPARC (derived from “soon as possible ARC”), the group’s tokamak machine, to the company’s facility in Devens, Massachusetts.

Author’s comment: As a former employee of Siemens and a Siemens Retiree, it is good to see that my prior-employer is participating in this leading-edge project.

The Devens’ campus is home to both the SPARC facility and the company’s magnet factory, where CFS builds the superconducting magnets that are key to the SPARC fusion machine.

CFS in 2025 signed a deal with technology giant Google to buy power from the Chesterfield County plant. Google first invested in CFS in 2021, and at the time of the 2025 deal said it would increase its investment in the company. The groups at that time said the agreement also gives Google rights to take power from future CFS-built reactors.⁶

Needham noted factors that set CFS apart from other companies, including overseas firms, that are working on fusion technology. Needham said it’s the company’s “approach, our execution, and our team. For our approach, we started by building our company on the best scientifically understood fusion machine available, the tokamak, so we don’t have to make new discoveries— and a schedule based on new discoveries is a lot more tenuous than a schedule based on engineering and delivery.”

Needham added, “We’ve upgraded the tokamak concept with stronger high-temperature superconducting magnets that enable a much smaller, more affordable machine than last-generation tokamaks. On execution, we’ve been successfully executing across many fronts—building and then testing our technology with prototypes; backing up our claims with peer-reviewed research; building our SPARC demonstration machine which is now ~75% complete; signing up partnerships and customers—enabling us to raise more funds than our competition, nearly \$3 billion, which is a significant portion of the total capital raised in the entire space...”

⁶ New investors in CFS include: Brevan Howard Macro Venture Fund; Counterpoint Global (Morgan Stanley); Stanley Druckenmiller; FFA Private Bank (Dubai) Ltd.; Galaxy Interactive, a venture platform within Galaxy Digital Inc. (NASDAQ: GLXY); Gigascale Capital; HOF Capital; Neva SGR (Intesa Sanpaolo Bank); NVentures (NVIDIA’s venture capital arm); Planet First Partners; Woori Venture Partners US; and others committed to the mission of commercializing fusion energy.

They join existing CFS investors who increased their stakes, including Breakthrough Energy Ventures; Emerson Collective; Eni; Future Ventures; Gates Frontier; Google; Hostplus Superannuation Fund; Khosla Ventures; Lowercarbon Capital; Safar Partners; Eric Schmidt, former CEO of Google; Starlight Ventures; Tiger Global; a large state pension fund and others who support CFS’ leadership in this energy transition.

Also, per Fortune (link below):

Backed by Nvidia, Google, Mitsubishi, Bill Gates, and more, Commonwealth Fusion Systems (CFS) leads the nascent fusion sector in funding, contracts, and has the advantage of being founded earlier than most in 2018 through a spinoff from the Massachusetts Institute of Technology.

<https://fortune.com/2026/01/07/fusion-power-commonwealth-sparc-nuclear-fusion-pilot-ai-siemens-nvidia/>