Fusion Research Industry 2025 Review

Nikita K. Alexandrov, MBA - July 18th, 2025

The world spends about 10% of its entire GDP on energy generation, over 6 Trillion Dollars. The shift to renewable energy is dramatically increasing, last year more than 30% of the world's energy was created through renewable sources, up from 19% in 2000.

The golden goose of an alternative energy fueled future has been the promise of clean nuclear fusion. The concept that you can convert matter like water or easily minable materials, directly into energy without nuclear waste byproducts. For example, one teaspoon of water converted directly to energy could theoretically produce as much energy as burning 13 Million liters of gasoline. While this is not currently technologically feasible, modern commercial fusion research aims to provide exponential improvements over modern energy economics.

A recent MIT financial analysis of a fusion energy supported power grid indicates that a fusion powered grid could almost triple the current global GDP ($106 Trillion), adding between $68 Trillion to $175 Trillion Dollars to the bottom line.

This research is based on the estimated economics from large scale "Confinement Fusion" or large devices which use magnets, lasers and other high energy systems to force molecules to fuse, releasing energy. These are generally large government and academic collaborative projects, but increasingly commercial players are pioneering their own fusion and alternative nuclear based systems.

There are around 20 large confinement fusion facilities operated through government and academic programs which have drawn the focus of the general public and scientific publications. Meanwhile, many commercial groups have been working on a paradigm challenging next generation clear nuclear systems with world changing ramifications. Exotic physics research sparked in the early 1990's is roaring to life and creating an emerging industry that is challenging modern thinking and creating unforeseen new clean technology possibilities.

Government Fusion Research Programs

Example: ITER - European International Thermonuclear Experimental Reactor
The European ITER, or International Thermonuclear Experimental Reactor was projected to cost 5 Billion Euros and be completed in 2016 on a 10 year timeframe. The completion date has been pushed back to 2033 with the official cost estimate ballooning to 20 Billion Euros, with some informal estimates indicating it may cost up to 56 Billion Euros.

Example: NIF - National Ignition Facility
The United States NIF, or National Ignition Facility was projected to cost 1.2 Billion USD and be completed in 2002. The completion date was 2009, with the research system costing 3.5 billion USD. The NIF is used for laser based fusion research as well as nuclear weapons research, being a critical part of the Stockpile Stewardship Program. The operating costs are substantial, with a single experiment potentially costing tens of millions of dollars.

First Wall Problem

While the fine print of many of these fusion research systems indicate that they are not actually expected to commercially power the electrical grid, they are promoted as research tools toward a sustainable power generating system. One key problem that challenges the majority of the efforts of Magnetic and Inertial Confinement Fusion is called the “First Wall” problem.

As the reactors are ignited and potentially even achieve “break even” using sustainable fuel such as hydrogen or hydrogen isotopes, neutrons and other high energy particles are released as well as helium as a clean waste product. Neutrons are known to be impossible to shield against, and any materials they make contact with become “neutron activated” or radioactive.

A significant amount of research has been done to create high temperature ceramics to line the reactors and survive the plasma energy and neutron activation. The problem is, the longer a material takes to “neutron activate”, the longer is required for it to decay, creating a radioactive materials waste problem.

For example the ITER reactor has 440 “Blanket Modules” or wall segments which protect from radiation and plasma weighing 4.6 tons each. They are made up of precision fabricated Beryllium as the first wall material, Copper/Chromium/Zirconium alloy as the heat sink and special stainless steel as the structural framework. These are designed for only 15,000 “full power cycles” before they need to be replaced and stored as radioactive waste. Currently, the world record for a fusion reactor “full power cycle” is 22 minutes.

The official story is that over time, as the walls become radioactive, robots will enter the reactor and replace the highly sophisticated and expensive lining materials. The cost balance of this commercially is not currently viable with the amount of investment required to “break even”, the price of the produced energy and the cost of high temperature wall materials. Some projects have developed “liquid walls” which allow for them to be drained and replaced more easily but still require a first wall to retain the liquid.

The goal of many of these reactors is to “Break even” or produce slightly more energy from fusing atoms together than it takes to push them together. While this is a great achievement in physics research, there are many hidden costs to this energy that are not factored into the energy generating economics which are important for real world deployment.

A commercially viable next generation clean nuclear system would need to produce at least 3 to 5 times more energy out than it took to power the system. This is because of the losses involved in converting the resulting heat energy back into electricity. Commercially viable systems would also need to have low capital costs and not require expensive shielding. Luckily, new paradigms in nuclear energy research are emerging which indicate this is a realistic possibility, with some projects coming off the back of decades of research into Aneutronic fusion as well as other more exotic methods.

Aneutronic Fusion

The most practical method to making fusion energy commercially viable is “Aneutronic fusion” or fusion that does not use brute force to smash hydrogen isotopes together, leaving a neutron emitting hangover. There are multiple strategies such as starting with an alternative fuel such as boron, thorium, etc and attempting to explore new physics. Of all of the government and privately funded fusion research programs, only a handful are able to potentially create "aneutronic fusion". Most others suffer from the "First Wall Problem" and will struggle toward commercial viability without significant grant funding, government subsidies, amortization and other methods to lower the capital costs of replacing reactor walls. While Aneutronic fusion is a scientifically recognized and approved phenomena, there are subjects of this area which are as exciting and loaded with possibilities are complex and polarizing. One example is Cold Fusion or more appropriately the field of LENR, which stands for Low Energy Nuclear Reactions.

Early History of "Cold Fusion"/LENR

In 1989, two Electrochemical researchers, luminaries in their field, pressured by their university technology transfer department, prematurely announced that they had discovered a way to produce fusion energy, without neutrons or other harmful radiation, in the space of a tabletop. They were using a method called electrolysis, which uses electricity to split water into oxygen and hydrogen and were able to release nuclear densities of heat energy in simple table top experiments. While many scientists raced to understand the discovery, the political knee jerk reaction from scientists all over the world caused an instant controversy which generally stifled grant funding and academic support for this type of research. The phenomena was originally called Cold Fusion, but is now generalized as **Low Energy Nuclear Reactions, or LENR**.

Quote:

Dr. Edmund Storms, Los Alamos National Laboratories, on the early days:

"When the claim of producing fusion in ordinary materials through electrolysis was announced by Fleischmann and Pons in 1989, everyone was surprised but hopeful that a new source of inexpensive and clean energy had been discovered. For example, this announcement created great excitement at the Los Alamos National Laboratory, where I worked. Much of the work focused on developing nuclear weapons was briefly applied to understanding this new discovery. Great surprise and disappointment resulted when the effort was terminated in spite of successful demonstrations.

Over the years, evidence proving that the process is real as well as the information needed for its application has been published. This information is readily available in the library at LENR.org."

LENR Materials / Effect Repeatability:

The fundamental roadblock in researching LENR is the fact that it requires a very specific combination of nanomaterials (usually Palladium based), activated in a very specific manner. While these conditions are now generally understood, it was not clear in the early days just how difficult it was to repeat the experiments without having the original successful materials. It was assumed that any palladium electrodes could trigger the effect, when in reality, only very specific batches of palladium could trigger the reaction due to their unique compositions.

Significant investment was made in trying to understand why some batches of palladium electrodes worked while others did not. Eventually it was found that Johnson and Matthey, the supplier of the successful Palladium, used a very old coal fired crucible to recycle Palladium in their supply chain. This old crucible contained decades of microimpurities which seemed to be the source of the mysterious catalyst in the palladium. Shortly after the Fleishman and Pons claims, they switched to a modernized industrial process which did not produce palladium which could recreate the desired effect. This led to researchers struggling to share active materials which were in very limited supply.

Modern LENR research is highly centered around creating material surfaces which contain the correct geometric structures, impurities/dopants and combinations of metal and non-metallic scaffolds. This is often a very long and trying "trial and error" process of making and testing many iterations of materials using precision material production techniques combined with advanced microscopy and other methods. Combinatorial experimentation, or doing many types of slightly different experiments in parallel, is used in biotechnology and other research industries. This method promises to dramatically shorten development cycles for LENR fuel materials and is being explored by academic and industry players with NASA publicizing their combinatorial method over 10 years ago. This NASA funded "Nuclear on a chip" research has the potential to not only rapidly increase research efficiency, but also translate directly into small scale energy generators.

Jed Rothwell, owner of LENR-CANR.org, explains the complexities of the field after reviewing over 2000 papers from the start, to the modern day. His paper, Lessons from Cold Fusion Archives and from History, is a very straightforward resource to understand the complexities of researching LENR.

Quote:
Dr. Edmund Storms, Los Alamos National Laboratories, on LENR Materials:

"We now know that helium is created and a large amount of energy is released when deuterium fuses. We understand that this reaction can occur in a variety of materials after suitable treatment. We also know that the process can take place simply by heating the active material in deuterium gas. Importantly, we have confirmed that dangerous radiation is not emitted, and the few radioactive products are easily contained. In other words, we have a source of energy based on the use of hydrogen in water as fuel, without the costs and dangers associated with nuclear reactors. Additionally, this fusion reaction does not require a complex generator that uses huge amounts of power to function, as is the case with the other type of fusion, commonly known as hot fusion. Furthermore, this cold fusion process can actually generate more energy than is required to initiate the fusion reaction."

LENR Research Developments:

The politics of the early research and materials reproducibility issues did not stop the US Navy (SPAWAR), NASA and many other strategic researchers from researching and publishing promising results in the field. In fact, many recognizable companies such as Toyota, Mitsubishi Heavy Industries, National Instruments, Google and others have had a long interest in this field and invested significant amounts in research and development.

In 2013, the US Television program "60 Minutes", hired Robert Duncan, then head of the American Chemical Society to review the research in the field of Cold Fusion/LENR. To his surprise, he found the experiments promising, later going on to head the first academic graduate program studying LENR/Cold Fusion, "Sydney Kimmel Institute for Nuclear Renaissance (SKNIR)" at the University of Missouri, which had already operated large experimental nuclear facilities providing world class nuclear isotope development services. In 2023, the US Department of Energy, through its ARPA-E program, allocated 10 million dollars toward those researching LENR or Cold Fusion.

NASA Glenn, one of NASA's 10 main research centers, with expertise in advanced nuclear research, recently published a technical review of its history of LENR experiments on the official NASA website. They cautiously noted positive results requiring more research, including nuclear isotopic changes on non-nuclear material surfaces, a potential breakthrough in applied physics. A more detailed paper is available here.

NASA Langley, another key research center, published an analysis of mission critical systems that LENR development could revolutionize. Shockingly, Dennis Bushnell, the chief scientist of NASA Langley at the time, was an outspoken proponent of LENR research. Dr. Joseph Zawodney, a chief scientist at NASA Langley, gave a brief interview shining light onto their LENR research systems and insights.

While traditional nuclear and strategic research industries are clouded in a shroud of secrecy and technical hyper competitiveness, the grass roots nature of LENR research has created a highly open and collaborative research environment. Mitsubishi Heavy Industries and Toyota, two traditionally competitive Japanese companies, are openly collaborating and investing resources in publishing validations of each other's LENR methods. This is more reminiscent of the open source computer software industry than traditional strategic research programs.

The European Clean HME Project is funded partially by government grants and involves over 10 prestigious research universities as well a handful of commercial companies. The project has received over $6M in funding and its collaborative goal is develop, test and understand a commercially viable LENR reactor system.

In terms of Private funding into fusion, LENR and cold fusion, over 7 Billion USD has been invested. TechCrunch recently reviewed 12 fusion research startup companies which have raised over 100M. While many of these companies suffer from the "First Wall Problem" of hot fusion, there are significant developments in aneutronic, LENR and cold fusion that are being commercialized.

Commercial Developments

There are Four Main Classes of Commercial Fusion Systems:

1. **Large Scale Hot Fusion Research Reactors**

These are the traditional government and academically funded “hot fusion” research programs based on confinement fusion and usually suffering from the “First Wall Problem”. These often require billions in capital investment and are not commercially competitive for energy production. There are around 15 of these programs in various stages of operation and designed for various tradeoffs between high energy yields and gleaning theoretical knowledge.

2. **Pilot Scale Alternative Fusion Reactors**

Most of the highly funded private Fusion Companies aim to produce pilot scale reactors that are not commercially viable, but prove the science and economics well enough to scale up and compete with modern energy generation systems.

These companies tend to require significantly less funding than the larger government driven approaches and have technology which could potentially overcome the various challenges with Hot Fusion. A handful of companies in this class are championing aneutronic fusion approaches which do not require expensive shielding and radioactive waste infrastructure.

These companies are often “moonshots”, betting on complex and highly theoretical advances in fusion equipment design, requiring tens to hundreds of millions in investment and long development cycles before they can validate their system can fire as expected. While the risks are high, the equation is very simple, if you can achieve specific energy output milestones at a specific cost and in a predictable and safe manner - your technology will become the industry standard for Hot Fusion and make all other approaches competitively obsolete.

3. **Small Scale/Modular LENR Reactors**

Many of the high risk/high reward companies operate in this class, representing the smaller subset of investment in the Fusion field. These companies are generally utilizing their own unique insights and engineering in the general field of LENR. Because these systems do not require high energy confinement, they have capital costs similar to conventional energy infrastructure and the research costs are generally low.

Many of these companies are developing modular systems which could be connected together to produce commercial power generation on the scale of 1-20 Megawatts, enough to power between a house and a small residential neighborhood.

While few companies have commercially viable LENR based electrical generation systems, a handful are skipping electricity entirely and working with industrial partners to deliver heat energy directly to industrial manufacturing processes. This early profitability and technological validation is critical for showing the financial markets that exotic physics based technology is investible.

These modular systems are highly attractive to developing countries as they can be deployed in remote areas and do not require a fuel infrastructure. Another key strategic benefit of LENR is that it can potentially be miniaturized and used in systems like space based energy systems, automotive systems and uninterruptible power supplies. The Space Power itself market is more than $5 Billion yearly, with aerospace industry leaders begging for the performance benefits that LENR based fuel cells can provide.

Many companies are working on thin film LENR based technology, which can leverage traditional microelectronics fabrication techniques to produce nuclear active materials. This “nuclear on a chip” approach could enable a new generation of consumer electronics and is being investigated, specifically by Asian academic and industrial research players. The Asian semiconductor industry has both a strategic foothold on the manufacturing of precision thin film materials as well as a vested interest in creating portable energy systems for the consumer electronics industry.

Conclusions:

The Fusion Industry is rapidly evolving, with new technical paradigms emerging and many commercial companies at their cusp of their validation stages. The last 35 years of LENR research seems to be rapidly crystalizing into a new industry, which is self supporting, highly collaborative and increasingly commercially promising.

Top 40 - Funded Fusion Energy Research Companies

Name	Valuation	Funding	Launch	Location
Commonwealth Fusion	$9,000,000,000	$2,000,000,000	2018	Harvard, USA
Helion Energy	$5,400,000,000	$1,000,000,000	2013	Everette, USA
Pacific Fusion	$4,500,000,000	$900,000,000	2023	San Diego, USA
TAE Technologies	$2,600,000,000	$1,100,000,000	1998	Lake Forrest, USA
Shine Technologies	$750,000,000	$425,000,000	2010	Janesville, USA
Zap Energy	$650,000,000	$338,000,000	2017	Seattle, USA
Marvel Fusion	$621,500,000	$235,000,000	2019	Munich, Germany
Xcimer Energy	$500,000,000	$118,000,000	2021	Denver, USA
General Fusion	$477,000,000	$370,000,000	2002	Richmond, Canada
Tokamak Energy	$435,000,000	$290,000,000	2009	United Kingdom
Kyoto Fusion	$395,000,000	$120,000,000	2019	Tokyo, Japan
Energy Singular Technology	$300,000,000	$55,000,000	2021	China
Type One Energy	$267,500,000	$82,500,000	2019	Knoxville, USA
First Light Fusion	$225,000,000	$101,000,000	2011	Yarnton, UK
Avalanche Energy	$200,000,000	$68,300,000	2018	Seattle, USA
Fuse	$200,000,000	$49,000,000	2018	Napierville, Canada
Proxima Fusion	$189,000,000	$40,100,000	2023	Munich, Germany
Blue Laser Fusion	$187,500,000	$62,500,000	2022	Goleta, USA
Renaissance Fusion	$176,000,000	$51,700,000	2020	Fontaine, France
Acceleron Fusion	$120,000,000	$24,000,000	2023	Cambridge, USA
nT Tao	$110,000,000	$22,000,000	2019	Hod Hasharon, Israel
Thea Energy	$100,000,000	$20,000,000	2022	Princeton, USA
Focused Energy	$75,000,000	$82,000,000	2021	Darmstadt, Germany
Brillouin Energy	$60,000,000	$13,700,000	2009	Massachusetts, USA
Novatron Fusion Group	$55,000,000	$23,100,000	2019	Stockholm, Sweden
Realta Fusion	$45,000,000	$12,000,000	2022	Madison, USA
Ex-Fusion	$36,500,000	$22,100,000	2021	Osaka, Japan
Open Star Technologies	$31,000,000	$6,200,000	2004	Wellington, NZ
Astral Systems	$30,000,000	$5,900,000	2021	Dorchester, UK
Helicle Fusion	$25,000,000	$21,400,000	2021	Tokyo, Japan
Helicity Space	$25,000,000	$12,200,000	2018	Pasadena, USA
HB11 Energy	$15,500,000	$3,100,000	2017	Sydney, Australia
Brilliant Light Power	N/A or Unknown	$100,000,000	1991	New Jersey, USA
Star Scientific	N/A or Unknown	$64,000,000	1999	Sydney, Australia
Industrial Heat	N/A or Unknown	$60,000,000	2013	North Carolina, USA
Google/MIT/Berkely	N/A or Unknown	$10,000,000	2019	USA
ENG8	N/A or Unknown	$7,000,000	2020	Portugal
SKINR	N/A or Unknown	$5,500,000	2012	Missouri, USA
Clean HME	N/A or Unknown	$6,400,000	2020	European Union
Neo Fusion	$688,000,000	$206,000,000	2023	China

Quote:

Dr. Dennis Pease, EXAFUSE Advisor on EXAFUSE operations:

"Working at the Sidney-Kimmel Institute for Nuclear Renaissance at the University of Missouri provided me the opportunity to become familiar with many novel types of energy production in both startups and academic institutions.

As a University of Texas Phd "Hot Fusion" plasma physicist I tracked the beginning and >34 year evolution of "Cold Fusion"/AHE/LENR with considerable interest. Throughout those decades I was continuously engaged in "hands on" research projects and product development while working for companies ranging in size from fortune 500 defense companies to first year startups.

From this diverse and long career perspective I have personally experienced the challenges involved in creating, cultivating, and commercializing several paradigm shifting technologies.

When SKINR ended at MU in 2017 I continued my involvement in LENR by attending all of the recent ICCF conferences. ICCF 25 marked my introduction to EXAFUSE CEO Chris Scott and after IWAHLM 16 we both met with EXAFUSE CTO Andras Kovacs and witnessed his novel experiments and unique physical explanations. I was initially very impressed by the mental acumen of Chris and Andras, excited by the novelty of their experiments, and have enjoyed their enthusiasm and zeal to follow unconventional results to their ultimate understanding no matter how complex that might be.

I believe that the talented and dedicated EXAFUSE team has great potential to short cut the time and cost of development of their proposed novel energy source that is based on an accelerated thorium decay that was first theoretically postulated and then experimentally validated.

Clearly EXAFUSE has a strong head start in understanding the acceleration of thorium decay rates and appears close to achieving the burden of proof required to initiate development deals and yield profitability with minimal time and financial investment."

Fusion Research Industry 2025 Review is sponsored by EXAFUSE, LTD

EXAFUSE is a next generation energy material research and development company exploring new fuel sources that can replace traditional nuclear fuels while retaining similar power densities.

EXAFUSE brings together an experienced leadership team and novel advances in energy physics to research, prototype and commercialize new fuel sources.

EXAFUSE has developed theoretical and experimental research programs and an intellectual property portfolio. EXAFUSE differentiates itself by investing in scientific communication, research publications, strategic partnerships, computer modeling and theoretical development. In this way, EXAFUSE has built a ground up expertise validated by scientific thought leaders and foundational physics.

This "Clean Cluster Fission" is a middle ground between traditional nuclear science and emerging physics. These developments can apply to "nuclear on a chip" type modular reactors, all the way to reactor systems rivaling the power output of current commercial reactors.

Thorium ore is well distributed across the globe and contains very high levels of usable material. One ton of Thorium can release as much energy as 3.5 Million tons of coal. It's estimated that the US has enough Thorium to power the entire country for 1,000 years. A single breakthrough discovery in China found enough Thorium to power the country for 60,000 years and they recently built the world's first commercially functioning Thorium Molten Salt Nuclear Plant.

By focusing on extracting energy from Thorium without nuclear waste or traditional infrastructure, EXAFUSE has a realistic and highly scalable commercial approach which is uniquely strategic for future global infrastructure energy needs.