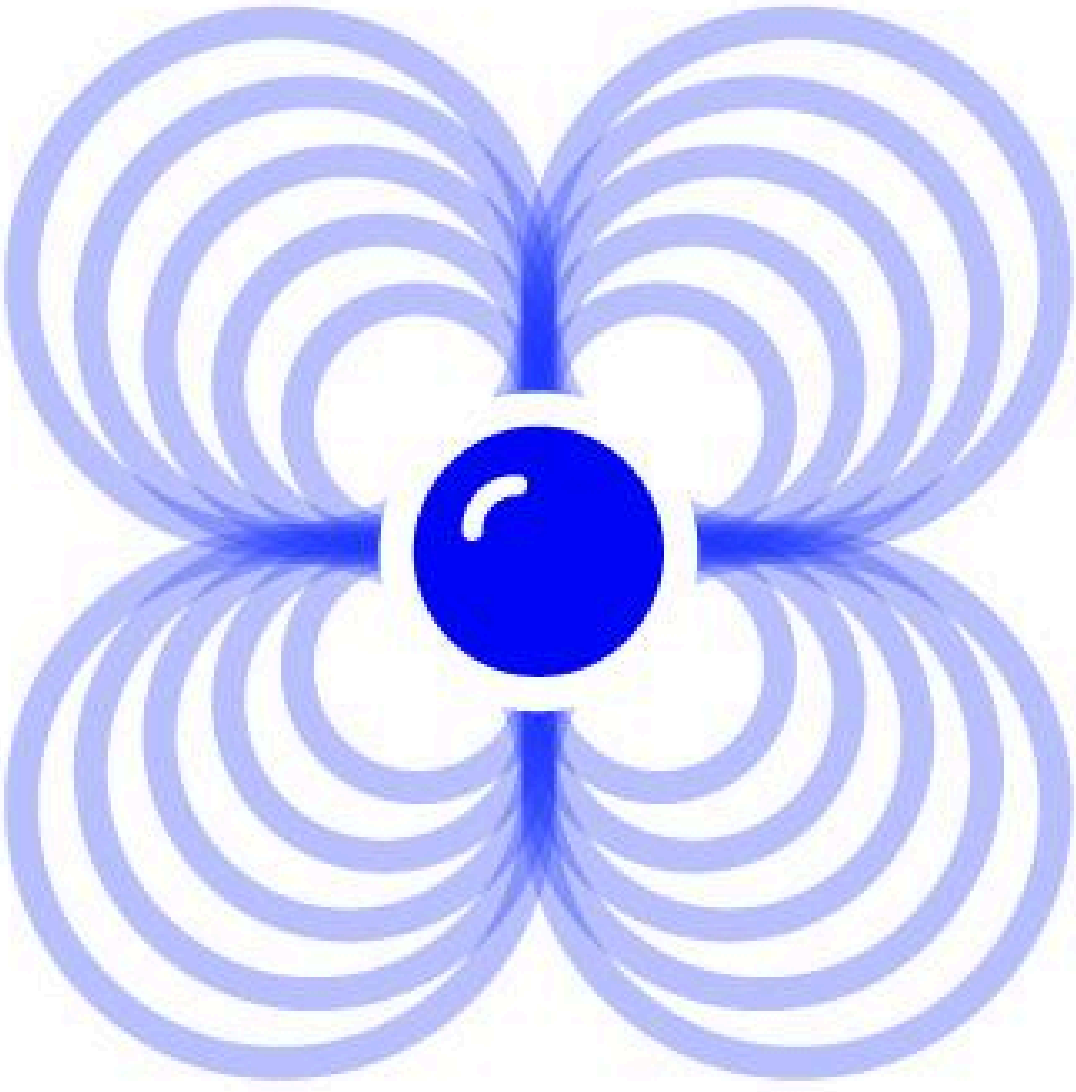
Chapter 1
Converting Matter Into Energy



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About SSF Discovery

SSF Discovery is supported by the Anthropocene Institute to drive awareness of Solid-State Fusion (SSF) and to drive talent and investments into the field. Through critical analysis and public engagement, SSF Discovery is a resource to inform a new generation of science, technology, engineering, and mathematics (STEM) students, as well as investors and policy makers on the potential of SSF to enable a transition to a clean, abundant, and reliable energy economy. Visit www.solidstatefusion.org to learn more.

The Anthropocene Institute is an incubator for cutting edge technological, policy, and financial innovations that address global environmental challenges: climate change, biological diversity, and human health. We provide due diligence to an investor pool, in the areas of scalable change that abate global warming and support clean energy, air, and water, as well as ocean conservation through our projects. Visit www.anthropoceneinstitute.com to learn more.

Executive Summary

In 1989, electrochemists Martin Fleischmann and Stanley Pons introduced the term “cold fusion” at a press conference where they described a reaction of palladium metal with deuterium, leading to a major outburst of energy that could not be explained by chemical means. In other words, they claimed to replicate the very process that powers the sun but at near room temperatures. However, when the scientific community could not replicate their work, cold fusion became a controversial topic for years to come and funding agencies categorically rejected all proposals.

Nevertheless, a minority of innovators persisted in studying the possibility of generating clean and inexpensive energy using readily found metals and isotopes of hydrogen. Today cold fusion is referred to as Solid-State Fusion (SSF) or low energy nuclear reactions (LENR). With the growing urgency to transition towards a cleaner, more reliable, and cheaper energy system, multiple public and private programs in energy innovations have included SSF in their portfolio in the past several years.

We may be at a tipping point as government funded research programs in the US, the EU, and Japan have been or are considering funding SSF. Most recently, a consortium of researchers funded by Google published in top-ranked journal Nature. Moreover, patents under the classification of low energy nuclear fusion were recognized by the USPTO starting in 2016 and have grown steadily since then. College and graduate students today have also expressed interest in the field and do not have memories of its past controversy.

The multiple developments in materials science, metallurgy, quantum physics, hydrogen systems, and semiconductor manufacturing suggest that SSF could become a disruptive industry that transforms our generation and use of energy in all sectors of our lives. This report is an overview of what we know about SSF and an assessment of the resources available for its emergence and its impact on the global energy system.

The SSF Discovery project explores the following questions:

- Who is involved in SSF?
- What are students’ interest in exploring this field and their motivations?
- What do we know about the science of SSF? What needs to be done?
- What does the patent landscape look like for SSF?
- What can we learn from previous technological breakthroughs and how can this be applied to accelerate the commercialization of SSF?
- What are the accompanying innovations needed for industrial heat applications and electricity generation from SSF?

- What is the capacity to develop the future SSF industry? What components of the supply chain need to be developed to realize a global SSF industry?
- What is the socioeconomic impact of SSF and how can deployment help us address our climate emergency?

SSF Discovery addresses these questions and more. Chapter 1 explores which companies, institutions, and organizations are funding, conducting research, and creating commercial products in this field.

Chap 1: Who's Involved in SSF?

Researchers, companies, and advocates of SSF have been active in the US, the EU, and Japan in the past three decades. These activities range from basic science research to commercialization efforts. In this chapter, we identify the players in the SSF ecosystem and their recent activities.

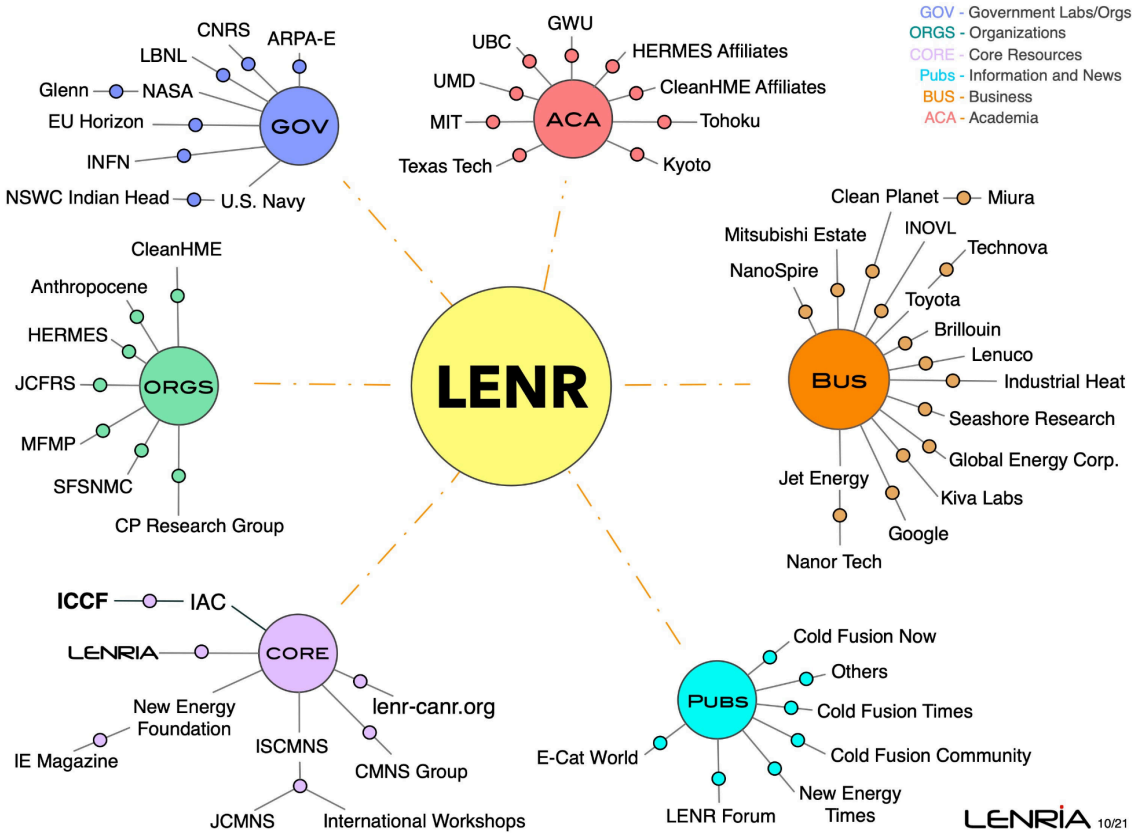

Fig 1. Ecosystem of organizations showing activity in SSF (source: LENRIA)

Basic research efforts

Privately-funded projects

In 2019, a consortium of researchers funded by Google published a prospective article on SSF in the peer-reviewed journal Nature.[1] Hailing from four major institutions, they did not observe the excess

[1] Berlinguette, C.P., Chiang, Y-M., Munday, J.N. et al. Revisiting the cold case of cold fusion. Nature 570, 45–51 (2019). https://doi.org/10.1038/s41586-019-1256-6

heat phenomenon, but this watershed moment renewed interest in a field that for three decades was shunned by the scientific establishment. These findings were revealed in 2019 in order to inspire others to investigate phenomena relating to SSF.[2]

Institution	Leadership	Technical expertise
University of California at Davis (UC Davis)	Jeremy Munday	Professor Munday's group investigates fundamental interactions between light and matter in photonic, plasmonic, and quantum materials in order to develop breakthrough energy generation and extraction technologies, and for clean energy technologies.
Accelerator Technology and Applied Physics Division, Lawrence Berkeley National Laboratory (LBNL)	Thomas Schenkel	Thomas Schenkel is a physicist and senior scientist at Lawrence Berkeley National Laboratory, where he is the Program Head for Fusion Science and Ion Beam Technology in the Accelerator Technology and Applied Physics Division.
Materials Science and Engineering, Massachusetts Institute of Technology (MIT)	Yet-Ming Chiang	Professor Chiang studies advanced inorganic materials for applications in energy technologies including batteries, high temperature superconductors, and low-cost metal 3D printing.
Department of Chemistry, University of British Columbia (UBC)	Curtis Berlinguette	The Berlinguette group focuses on research in solar cells, solar fuels, electrochemistry, energy storage, CO2 utilization, and high throughput chemistry.

Table 1. Google-supported research organizations that study SSF.

Under this consortium, the researchers tested three mechanisms for understanding SSF – two involving palladium and hydrogen, and one involving metallic powders and hydrogen.[3]

[2] Editorial, Nature, This Week–Editorials, Vol 569, May 2019, p.599-600.
[3] Elizabeth Gibney, Google revives controversial cold-fusion experiments, Nature, News Article, Vol 569, May 2019, p.611.

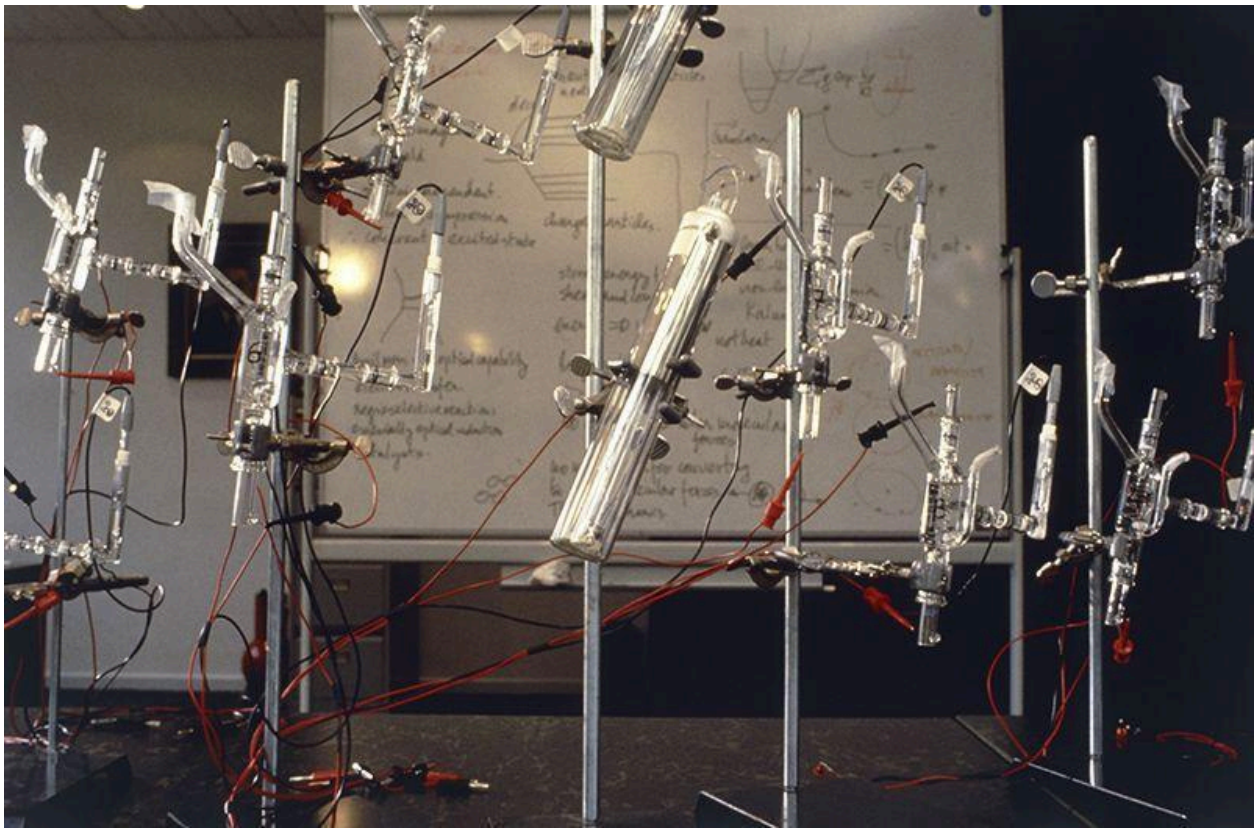

Fig 2. (source: Nature/Philippe Plailly/SPL)

The scientists' first experimental approach tried loading palladium with small amounts of deuterium, which they hypothesized to be necessary to trigger fusion. But at higher concentrations, scientists were unable to create stable samples.

In the second experimental approach, scientists followed up on 1990s work by US physicists, including former Los Alamos National Laboratory scientist Tom Claytor, who claimed to have generated anomalous levels of tritium — another heavy hydrogen isotope, only created through nuclear reactions — by bombarding palladium with pulses of hot deuterium ions. The analysis of nuclear signatures showed no tritium production and the authors hypothesized that the tritium effects could have been too small to measure with their equipment. The team suggested that further work could produce more stable samples at extremely high deuterium concentrations, where interesting effects might occur.

In the third approach, researchers heated up metallic powders in a hydrogen-rich environment. Some of the companies currently designing and developing SSF technologies have demonstrated that the process of catalyzing metallic powders under pressure produces excess heat from the fusing elements. After 400 tests, the scientific researchers were unable to detect any heat excess, however they did observe phenomena that current theory does not explain.

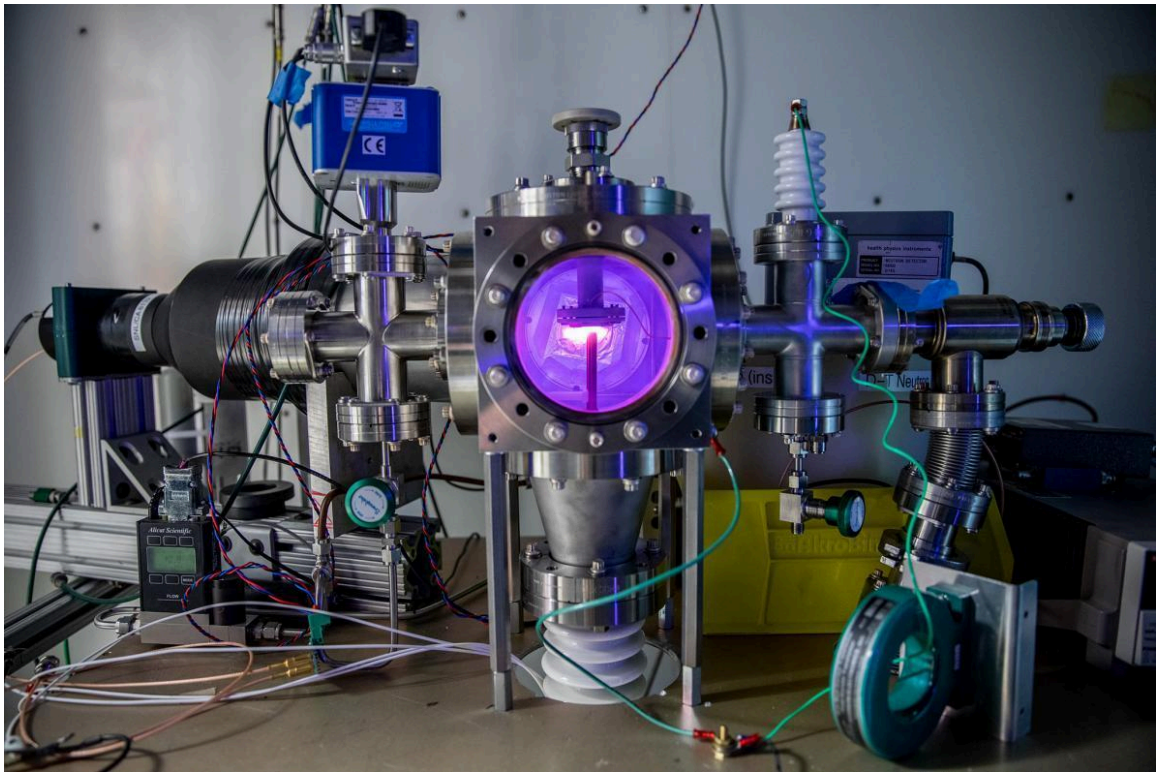

Fig 3. Image Credit: Marilyn Chung/Lawrence Berkeley National Laboratory

Although the scientists were unable to create stable samples or provide conclusive evidence for excess heat, they indicated that both of the palladium experiments warrant further study. Nevertheless, these kinds of studies drive improvements in measuring excess heat and finding evidence for nuclear reactions, which are critical steps forward towards the science and commercialization of SSF-powered devices.

Publicly-funded research

Although the US Department of Energy (DOE) held two reviews of SSF in 1989 and 2004, they had concluded that the field was of interest but no funding opportunities arose. In what is arguably the most significant activity in the public sector on SSF, the DOE's Advanced Research Projects Agency - Energy (ARPA-E), held a workshop in October, 2021 to "explore compelling R&D opportunities in LENR".[4] The discussions at the workshop will be used as a basis by the agency, which was originally mandated to fund disruptive energy technologies, to decide if SSF is a category of research to be funded and how.

[4] https://arpa-e.energy.gov/events/low-energy-nuclear-reactions-workshop

While an ARPA-E funded project would be a shot in the arm for SSF, the momentum has already been building up. SSF Discovery has already been supported by government agencies in the US, the EU, and Japan.

Organization	Region	Years Active	Budget	Description
Naval Surface Warfare Center, Indian Head Division	USA	2021-	??	The HIVER Electrochemistry Energy Project is a consortium of researchers from the U.S. Naval Academy, the U.S. Army Research Laboratory (ARL), and the National Institute of Standards and Technology.
Clean Hydrogen Metal Energy (HME)	EU	2020-2024	€ 5.5 million	With climate change being a major driver, this EU effort sees hydrogen–metal energy (HME) as potentially powering small mobile systems as well as in stand-alone heat and electricity generators.
HERMES	EU	2020-2024	€ 4 million	HERMES will employ advanced techniques and tools developed over the last few decades to investigate anomalous effects of deuterium-loaded palladium at room and intermediate temperatures.
New Energy and Industrial Technology Development Organization (NEDO)	Japan	2015-2017	¥1.5 billion	Over a period of three years, the NEDO funded a consortium of four universities and two car companies.

Table 2. Government funded organizations actively involved in SSF Discovery.

US

With energy and fuel critical for military operations, especially in remote locations or areas of conflict, posing significant logistical challenges, new forms of energy production and storage such as SSF Discovery technologies are of keen interest to the US Department of Defense (DOD). Five US government labs led by the US Naval Surface Warfare Center (Indian Head), announced that they would be conducting their own SSF efforts beginning in 2021 with results to be announced at the end of the year. [5]

[5] Michael Koziol, Whether Cold Fusion or Low-Energy Nuclear Reactions, U.S. Navy Researchers Reopen Case, IEEE Spectrum, Tech Talk, Energy-Nuclear, March 2021.

NASA has also supported SSF Discovery research in two of their labs with results that have been published in peer reviewed journals. In 2020, NASA's Glenn Research Center demonstrated an innovative nuclear powered application for deep space exploration based on lattice confinement fusion (LCF).[6]

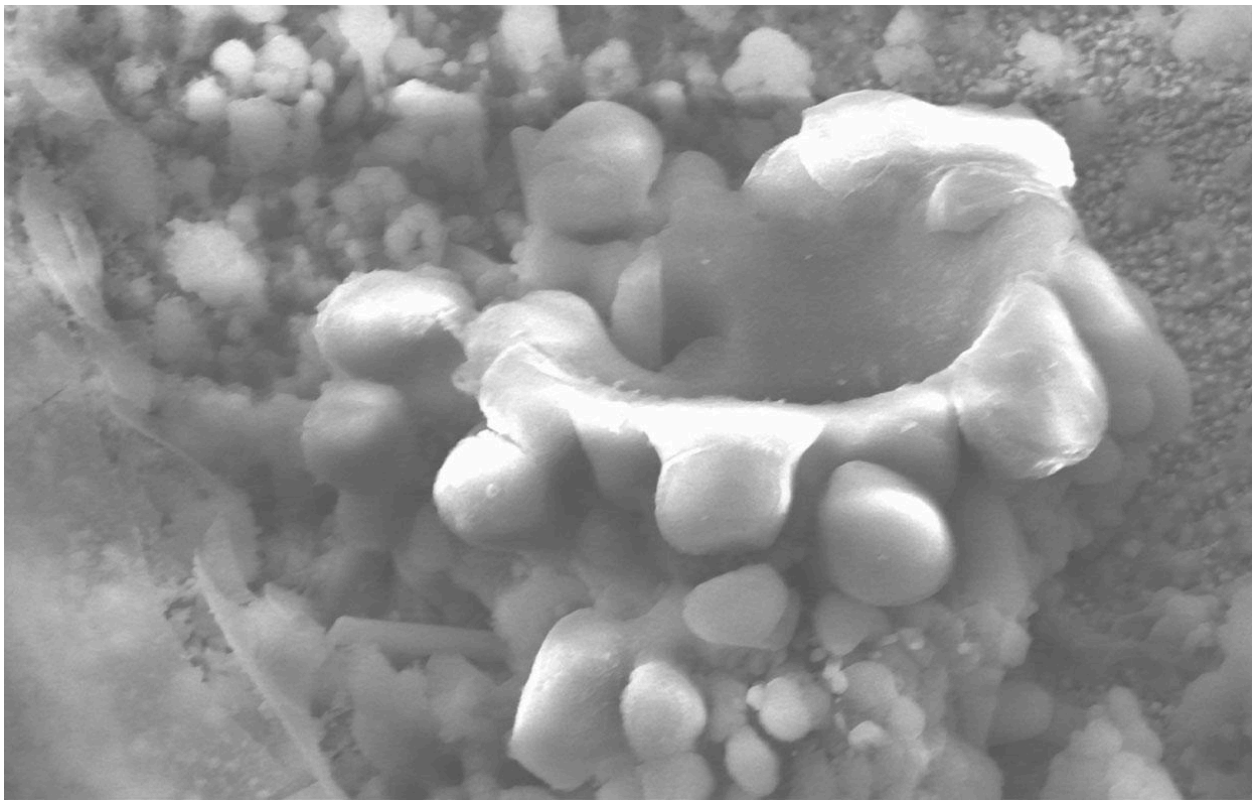

Fig 4. Craters on the surface of a sample of palladium which may have resulted from low energy nuclear reactions. Image Credit: SPAWAR/US Navy

EU

In the European Union, there are currently two Horizon2020 funded SSF consortiums: the HERMES and the Clean HME programs. The HERMES projects employ advanced techniques and tools to investigate SSF's anomalous effects and develop a comprehensive theory for clean hydrogen-metal energy technologies.[7]

[6] NASA's research was published in two peer-reviewed papers in the top journal in the field, Physical Review C, Volume 101 (April, 2020): "Nuclear fusion reactions in deuterated metals" and "Novel nuclear reactions observed in bremsstrahlung-irradiated deuterated metals. NASA Detects Lattice Confinement Fusion, NASA Glenn Research Center, July 2020.

[7] The EU has funded the HERMES project to employ advanced techniques and tools to investigate the anomalous effects associated with SSF and launch the clean hydrogen-metal energy (HME) project to produce a comprehensive theory. HERMES Grant agreement ID: 952184, Funded under H2020-EU.1.2.2., Coordinated by Turun Yliopisto Finland, Nov 2020 to Oct 2024.

University	Leadership	Country	Description
Aalto University	Tanja Kallio	Finland	Received €385,000 of funding from the EU as part of the HERMES project for research on "breakthrough zero-emissions heat generation with hydrogen-metal systems" based on deuterium/palladium electrolysis.
Brno University of Technology	Ing Jan Macak	Czech Republic	Researchers in advanced low energy nanomaterials having received € 694,000 of EU funding as part of the HERMES project for research on "breakthrough zero-emissions heat generation with hydrogen-metal systems" based on deuterium/palladium electrolysis.
Imperial College London	Stephen Skinner	UK	Received €712,000 of EU funding as part of the HERMES project for research on "breakthrough zero-emissions heat generation with hydrogen-metal systems" based on deuterium/palladium electrolysis.
National Centre for Scientific Research (CNRS)	Frederick Maillard	France	CNRS' research focus is on electrochemistry and electrocatalysis at solid-liquid interfaces having received €662,000 for research on "breakthrough zero-emissions heat generation with hydrogen-metal systems" based on deuterium/palladium electrolysis as part of the HERMES project.
Technical University of Munich	Aliaksandr Bandarenka and Batyr Garlyyev	Germany	Received €688,000 of EU funding as part of the HERMES project for research on "breakthrough zero-emissions heat generation with hydrogen-metal systems" based on deuterium/palladium electrolysis.
University of Limerick	Matthias Vandichell	Ireland	Received €456,000 of EU funding as part of the HERMES project for research on "breakthrough zero-emissions heat generation with hydrogen-metal systems" based on deuterium/palladium electrolysis.
University of Turku	Pekka Peljo	Finland	University of Turku's Dept. of Mechanical and Materials Engineering is leading The HERMES Project, a multinational team of scientists studying the electrochemistry of Pd-H and Pd-D systems in detail, utilizing well-controlled model systems such as palladium single crystals.

Table 3. Members of the HERMES consortium.

Japan

During the 1990s, the Japanese government supported SSF research through its Ministry of International Trade and Industry (MITI). With initial results disappointing, the project was ended; however, government interest in SSF has returned in the past decade.
Between 2015 and 2017, the New Energy and Industrial Technology Development Organization (NEDO), a government agency devoted to the development of non-nuclear energy technologies, funded a program to study SSF. The program was called “Phenomenology and Controllability of New Exothermic Reaction between Metal and Hydrogen” and was carried out by a consortium of four universities and two auto manufacturers “to verify the existence of new exothermic reaction between nano-metals and hydrogen” for the purposes of developing a new clean source of energy.[8]

Organization	Leadership	Description
Nissan Motor Corporation	Masanori Nakamura	Nissan is the world’s largest car company and has collaborated with Kyushu University on SSF research. They have investigated anomalous heat production from nickel-zirconium alloys and hydrogen gas.
Technova Inc	Akito Takahashi	Technova, a subsidiary of Toyota Motor Corp), has been involved in SSF R&D for decades and has provided research grants and advocated for government support. Group leader Akito Takahashi and team have proposed the theory of the Tetrahedral Symmetric Condensate (TSC), which models the symmetric compression of four hydrogen atoms until they fuse.
Tohoku University	Yasuhiro Iwamura and Jirohta Kasagi	Tohoku University collaborates with Clean Planet and Mitsubishi Heavy Industries having experimented with hydrogen gas permeation through a multilayer structure of palladium and calcium oxide.
Kyushu University	Masahiro Kishida	Professor Kishida’s research at Kyushu University focuses on the synthesis and characterization of metal nanoparticles for dehydrogenation reactions and hydrogen production.
Kobe University	Yuichi Furuyama	Professor Furuyama has been investigating anomalous heat evolution from metal composites and hydrogen gas.
Nagoya University	Tatsumi Hioki	Professor Hioki is a researcher at the Green Mobility Research Institute, Institutes of Innovation for Future Society at Nagoya University. Established in 2011, the research center focuses on innovation in the areas of advanced vehicles, mobility services, and social impacts..

Table 4. Members of the NEDO consortium.

In NEDO’s final report that was published in 2019, the group concluded that SSF under metal-hydrogen systems showed heat outputs that were about four orders of magnitude greater than expected from chemical energy per atom of hydrogen reacted. The results of the consortium were published in the International Journal of Hydrogen Energy.[9]

[8] https://www.nedo.go.jp/library/seika/shosai_201808/20180000000049.html
[9] Kitamura et al, Excess heat evolution from nanocomposite samples under exposure to hydrogen isotope gases, International Journal of Hydrogen Energy, 43 (33) 2018, pp 16187-16200

Commercial Entities

Commercial entities Brillouin Energy, Brilliant Light, Clean Planet, Global Energy Corporation, and Jet Energy among others are SSF companies that have reported observing excess heat and have stated their intentions to commercialize their technologies. Table 2 shows companies that have publicly reported their investments.

Company	Country	Investments
Brillouin Energy	US	$25 million
Clean Planet	Japan	$12 million

Table 2. SSF companies with publicly disclosed investments

In 2019, Tokyo-based Clean Planet announced that the Miura Group had licensed its SSF technologies developed in conjunction with Tohoku University for $4.5 million. Miura Co is the largest boiler company in Japan and has developed, manufactured, and marketed a wide range of products in the heat, water, and environment fields around the globe since 1959.

Berkeley, California-based Brillouin Energy, has sold licenses for its Hydrogen Hot Tube Reactor technologies in the Asia-Pacific region to OEMs to design their own highly energy-efficient products. SSF technology developers developing innovative reactor designs capable of producing electricity economically, such as Brillouin Energy and Clean Planet, also have the potential to vertically integrate and become much more involved in energy production too.

See Appendix A for list of all existing companies in the SSF ecosystem

Professional Organizations

Organization	Leadership	Description
International Society for Condensed Matter Nuclear Science (ISCMNS)	William Collis	Media co-operative to promote the understanding, development and application of CMNS for the benefit of the scientific community that publishes the Journal of Condensed Matter Nuclear Science (JCMNS).
Japan CF Research Society	Shinya Narita	The JCF, where CF stands for Condensed-matter (solid state) Fusion, Coherently-induced Fusion, or Cold Fusion, investigates the nuclear reactions that occur in the solid-state and, ultimately, to develop techniques to extract usable energy from these reactions.
Journal of Condensed Matter	Jean Paul Biberian	Open-access electronic journal that accepts scientific papers of high quality concerned with subjects relating to nuclear processes in condensed matter.

Nuclear Science (JCMNS)		
Low Energy Nuclear Reaction Industry Association (LENRIA)	Steve Katinsky and David Nagel	Industrial association formed to advocate on behalf of the SSF community in the US. Engaged with SSF researchers Dr. Melvin H. Miles and Dr. M. Ashraf Imam on Pd-B studies.

Investors

Organization	Leadership	Description
Deep River Ventures	Dewey Weaver	Intellectual properties consulting firm.
Cherokee	Tom Darden	Tom Darden, the founder and CEO of the $2.2 billion private equity fund Cherokee Investment Partners, made his mark by acquiring and cleaning up hundreds of environmentally contaminated sites and is now a major investor in clean energy technologies.
LENR Invest	Michael Halem	Invests in SSF makers to bridge the gap between lab demonstration and industrial prototype, including investments in LENR Cars, Brillouin Energy, Lenuco LLC, and NicHenergy.

Media and News Websites

Site	Leadership	
LENR-Forum	David Nygren	News portal website connecting the global SSF community.
Infinite Energy	Christy Frazier	Published by the New Energy Foundation and founded by Eugene Mallove, the publication is a catalyst for advancing and disseminating knowledge of all facets of new energy, including SSF. Infinite Energy promotes a proactive exchange of ideas and promulgates advances in research via assessments, guidance, publicity, and grants.
LENR-CANR	Jed Rothwell	An online resource of scientific papers on SSF or chemically assisted nuclear reaction (CANR), featuring 1,900 original entries reprinted with permission from the authors and publishers.
New Energy Times	Steven Krivit	Founded in 2000, New Energy Times is the leading on-line reference site for SSF research. An independent source, the site is a resource for students, scientists, scholars, policy analysts, businesses, and government agencies. From the home page, there is a well-organized collection of information, consisting of more than 700 Web pages and 2,000 PDF documents.

See Appendix B for a complete list of media and news sites on SSF.

Acknowledgements

SSF Discovery would like to thank Grant W. Draper for identifying and analyzing SSF related organizations for this chapter. Mr. Draper has both a Master of Business Administration from Columbia University, New York and a Bachelor of Arts in Political Science from the University of Alberta, Canada.

Steven Katinsky has also contributed to mapping out the SSF ecosystem and provided useful discussion of the different organizations. He is co-founder and director of LENRia.org and was previously chair of The 21st International Conference for Condensed Matter Nuclear Science. Mr. Katinsky received his Bachelor of Arts in Communications from Rutgers University.

Appendix A

Company	Description
Brillouin Energy Corporation	Proprietary Q-Pulse technology based on Ni/H SSF. Developing commercial SSF technologies, including the Hydrogen Hot Tube (HHT) reactor for the energy market. Announced licensing deals for Korea and SE Asian geographies. European patent(s) and US patent applications. Contracted with SRI and scientists Michael McKubre and Francis Tanzella to conduct independent reproducibility tests.
Clean Nuclear Power LLC	Lugano-based company prototyping a SSF energy device for commercialization and industrialization. Working with SSF Cities Suisse funded by George de Montmollin with European patent(s) and US patent applications.
Clean Planet, Inc.	Clean Planet was founded by Hideki Yoshino in 2021and has partnered with Tohoku University for the R&D, prototype and commercialization of SSF using “Quantum Hydrogen” technology. They have been invested by Mitsubishi Estate and announced a licensing deal with Miuru Boilers in 2021.
Cooper Core Technologies, Inc.	The team, led by Dennis Cravens, has been working on SSF experiments since 1989 and has demonstrated multiple active cell SSF systems throughout the years.
Deneum Power	The company is prototyping a device based on the reaction of sintered titanium with hydrogen and the reaction of hydrogen with nickel powder in an electrically heated silicon carbide pipe. Initial funding was targeted for $90M through an initial coin offering (ICO).
Global Energy Corporation (GEC)	Led by Lawrence Forsley and DR. JAY W. KHIM, Global Energy Corporation (GEC) has developed a hybrid fusion/fission reactor powered with used fuel from conventional atomic plants. GEC builds upon 20 years of R&D and product development in conjunction with US Navy SPAWAR carried out by Pamela A. Boss, Frank E. Gordon, Stan Szpak and other SPAWAR scientists.

Google LLC/Alphabet, Inc.	Google has supported a multi-institutional effort that included Lawrence Berkeley National Laboratory, University of Maryland, MIT, and University of British Columbia. Their effort has culminated in nearly 30 publications in peer reviewed journals.
Heliorite AB	SSF technology developer designing hardware for environmentally friendly energy plants to software that might be developed into commercially competitive energy technologies.
Industrial Heat, LLC	IH manages an SSF portfolio to support SSF researchers developing advanced new, carbon-free and efficient energy sources. According to its public filings, IH invested in SSF researchers and startups (as of 2017 the estimated fundings were: $500,000 to Dennis Letts, $2,000,000 to Cooper Core Tech Inc., $1,000,000 to UniTSEM, $300,000 to Peter Hagelstein, $1,000,000 to Tadahiko Mizuno, $1,500,000 to JET Energy, $1,000,000 to Chava Science, $500,000 to Lenuco, $500,000 to Brillouin Energy, $1,000,000 to PointSource, $500,000 Francesco Piantelli).
Jet Energy Inc.	Led by Mitchell Swartz, JET Energy has developed the NANOR® and PHUSOR® SSF/ LANR (lattice assisted nuclear reaction) devices. The NANOR device contains dry zirconium dioxide powder with embedded palladium nanoparticles, which are deuterium-loaded. Received funding from Industrial Heat, LLC. NANOR and PHUSOR are registered trademarks of JET Energy, Inc. They are protected by U.S. Patents D596724, D413659 and several other patents pending.
Kiva Labs, USA	Led by ex LANL nuclear chemist Edmund Storms, Kiva Labs conducts experimental research in SSF. Storms is the author of The Science of Low Energy Nuclear Reaction.
LENR Cars SA	Developer of mobile SSF power generators based on SSF technology for transport vehicles (aircraft, boats, trains and cars) without CO2 emissions or waste.
Lenuco	Lenuco develops SSF technology capable of producing energy at room temperature without any heat or electrical input for use by NASA. Holds several patents on SSF core technology and has received funding from Industrial Heat and SSF Invest.
Nanospire	NanoSpire, Inc. was founded in December, 2001 to commercialize a new generation of cavitation reentrant jet-based high shear nanotechnology tools and processes.
Net Zero Chem	NetZeroChem researches methods of making valuable commodities in a truly sustainable way. Methods that are carbon negative or neutral, and profitable. With its engineering partners RB Plant, it has developed a system to produce green hydrogen from aluminium waste streams.
New Inflow	Proposed new mathematical theory, reported on anomalously high excess heat release in gas flow plasmoid formations and transmutations being observed. SSF devices run on a wide range of materials, not limited to palladium and nickel.
Nichenergy S.R.L	Nichenergy is researching and developing its own innovative proprietary process for producing energy from nickel-hydrogen in a SSF reaction. Holds several patents: PCT/IT95/00008, PCT/IB2009/007549,

	PCT/IB2012/052100, PCT/IB2012/053615, ITPI2011A000107. The company reported having achieved excess heat in the order of 70 W with input of 30 W for almost one year with nickel rods in a hydrogen gas atmosphere. They also received funding from SSF Invest and Industrial Heat.
Nissan Motor Corporation	Participated in SSF research through the national research and development agency NEDO.
Norrønt Fusion Energy AS (NFE)	Developer of muon-catalyzed fusion (μCF) is a process allowing nuclear fusion to take place at temperatures significantly lower than the temperatures required for thermonuclear fusion, even at room temperature or lower. It is one of the few known ways of catalyzing nuclear fusion reactions starting from pure Deuterium.
Purratio AG	Solfire SSF technology is based on water-vapor-operated plasma jet discharge using heavy water or light water and a palladium cathode.
Technova Inc	Technova, a subsidiary of Toyota Motor Corp), has been involved in SSF R&D for decades and has provided research grants and advocated for government support. Group leader Akito Takahashi and team have proposed the theory of the Tetrahedral Symmetric Condensate (TSC), which models the symmetric compression of four hydrogen atoms until they fuse.
TOP Consulting	Passell is running experiments to demonstrate the Oppenheimer-Philips strip reaction in SSF. In this process the neutron half of an energetic deuteron (a stable isotope of hydrogen with one proton and one neutron) fuses with a target nucleus, transmuting the target to a heavier isotope while ejecting a proton.
Unified Gravity Corporation (UGC)	Developer of a hydrogen-lithium fusion device (HLFD) which generates proton-lithium plasma within a reaction chamber. There are several patents from these researchers: Hydrogen-lithium fusion device (WO2014189799A9), Fusion heat engine and electrogravity generator methods and applications (WO2010008625A2), Hydrogen-lithium fusion device, method and applications (US20090274256A1), Hydrogen-lithium fusion device (CA2912694A1).
UniSTEM	Developing SSF triggering technology based on La Gatta's original prototype experiment is believed to have generated a COP (energy gain) of 1000 with 70 mW input power over 10 minutes. Located in Lubbock, Texas.

Appendix B

Website	Description
Atom Ecology	Blog on hydrogen isotope/mixed metal cold fusion and hydrogen catalysis and production.

Cold Fusion Community Wiki	The Cold Fusion Community maintains a SSF directory wiki featuring many of the organizations and individuals active and "lost" in SSF discovery and commercialization fields.
Cold Fusion Podcast/Blog	Ruby Carat surveys scientists and technologists in the cold fusion/SSF community to discuss the current state of research and development.
Discover Cold Fusion	An illustrated novella describing the origin story surrounding the drama and excitement of the discovery of cold fusion from Curtis-Press.
E-Cat World Blog	Blog covers news, information and discussion about advanced energy technology, focusing on the Energy Catalyzer (E-Cat) invention of Andrea Rossi.
Ego Out	Active between 2010 and 2018, Peter Gluck's Ego Out blog made a significant contribution to further advancing the fields of SSF.
Infinite Energy	Published by the New Energy Foundation and founded by Eugene Mallove, the publication is a catalyst for advancing and disseminating knowledge of all facets of new energy, including SSF. Infinite Energy promotes a proactive exchange of ideas and promulgates advances in research via assessments, guidance, publicity, and grants.
LENR-CANR	An online resource of scientific papers on SSF or chemically assisted nuclear reaction (CANR), featuring 1,900 original entries reprinted with permission from the authors and publishers.
LENR-Forum	News portal website connecting the global SSF community.
LENR-Wiki	German language Wiki about SSF featuring news, information and research.
New Energy Times	Founded in 2000, New Energy Times is the leading on-line reference site for SSF research. An independent source, the site is a resource for students, scientists, scholars, policy analysts, businesses, and government agencies. From the home page, there is a well-organized collection of information, consisting of more than 700 Web pages and 2,000 PDF documents.
Sifferkoll	Sifferkoll is about using quantitative analysis and proprietary algos on big data to verify qualitative and intuitive models covering areas of interest, including trading, online sales, social media behaviour and black swans like the SSF paradigm shift.