Essential Public Policy Changes for Development and Deployment of LENR Energy

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1. Introduction

Cold fusion was announced by Martin Fleischmann and Stanley Pons at the University of Utah in March 1989. The energy production potential of cold fusion (now frequently referred to as Low Energy Nuclear Reactions, LENR) was clearly realized at the time.[1] As a potential new source of energy, LENR offers many advantages[2]:

- Virtually unlimited energy supply
- Environmentally secure (no emissions or effluents)
- No harmful radiation or radioactive waste
- Possibly deployable in centralized or dispersed configurations
- Low cost of materials
- Operational advantages (low maintenance)
- High energy return (output vs. input)
- Energy source available everywhere without transport or restriction

When cold fusion was announced, memories were still fresh about the oil embargoes and long lines at gas stations of the 1970s. The main emphasis at the time was on LENR's potential as an additional supply of energy. Fossil fuel supplies were perceived to be dwindling rapidly and needed to be supplemented. With the emergence of global climate change (GCC) as a principal issue, the situation has shifted dramatically. GCC, which is caused (or at least initiated) primarily by greenhouse gases from fossil fuels, threatens the very habitability of the earth. The urgency is now for LENR to replace or displace fossil fuels and their greenhouse gas emissions.

Notwithstanding its potential advantages, LENR was rejected by mainstream science within a year or so.[3,4] The reasons for the rejection are rooted in the ways that science is conducted—the sociology of science.[5,6] Incremental science is readily accepted, whereas revolutionary discoveries are not.[7] LENR is certainly a revolutionary discovery and requires that current scientific understanding be significantly changed or extended. In retrospect, LENR rejection was an instance of failure in the sociology of science. The error has been compounded by the failure of self-correction of science in the decades since. LENR's primary issues continue to be insufficient reproducibility and inadequate understanding.

Despite the rejection by mainstream science, LENR has continued to be pursued by many highly qualified scientists around the world. Continued research, experimental results and progress in theory development indicate that LENR may yet realize its potential as a new source of energy. Particularly because of the existential threat of GCC, policy changes for research support for LENR are essential. And because its deployment as an energy source will almost certainly have a disruptive effect on the current energy infrastructure and associated elements of society, new policies are also needed for mitigation of these effects. The case is made here for LENR policy changes by describing the current situation, advocating policy changes for LENR research, delineating the policies needed to deal with its disruptive impacts[8] and setting forth important corollary policy considerations.

2. Cold Fusion Policies: Where Do We Stand?

The public interest of government support for scientific R&D has long been recognized. Salient historical examples are the Manhattan Project, which brought World War II to an end, and the U.S. space program, whose research has led to many benefits beyond the immediate goals of the program. Government support is particularly important in the early stages of technology development when risks are high and research costs may not be justified for private sector investment.

Because of its potential as a new energy source, LENR development is very much in the public interest. When it was rejected, however, public policies for research support generally followed suit. The rejection was followed by withdrawal of public support—the error of rejection was amplified in the error of negative support policies. Because the energy prospects of LENR were negated, preparation for its potential disruptive effects was also minimal.

The U.S. Department of Energy (DOE) was a leader in LENR rejection in at least two major events. First, through its Energy Research Advisory Board (ERAB), the agency investigated LENR and issued its final report in 1989.[9] It recommended no special funding for LENR research. In practice this recommendation resulted in no funding of any consequence at all.

Second, in 2004 the DOE went through another process involving two groups of perceived experts.[10] The conclusion was that no change from the 1989 recommendations was needed. Critiques of the effort[11,12] found a number of deficiencies in how the review was conducted and the conclusions drawn. For example, close examination of the inputs received from the participants indicates that the final report recommendations appear not to be consistent with the input received. [It is noted that in a February 2023 apparent policy reversal, DOE's Advanced Research Policy Agency–Energy

(ARPA-E) funded eight projects to investigate LENR[13] for a total of about $10 million.]

However, the historical negative stance of the DOE influenced policies of agencies and entities not only in the U.S., but around the world. For example, the U.S. Patent and Trademark Office has refused to grant patents for LENR devices.[14] The National Science Foundation has not considered LENR to be legitimate science and has not generally supported research in the field.

Despite DOE's long-standing policy example, other federal agencies have supported LENR research on and off in the decades since 1989. These agencies have strong interests in energy development and may serve as examples for future LENR research support. For example, components of the U.S. Navy conducted internally funded research on the phenomenon at no fewer than three locations—Space and Naval Warfare Systems Command (SPAWAR), San Diego, California; Naval Air Weapons Center, China Lake, California; and Naval Research Laboratory, Washington, DC.[15] NASA has periodically conducted and supported research starting soon after the announcement.[16] Research has been done at both the Glenn Research Center, (Cleveland, Ohio) and Langley Research Center (Hampton, Virginia). Two relevant publications describe recent NASA research on lattice confined fusion.[17,18]

3. Policy Changes for LENR Development

Public support for a scientific claim must be based on the evidence that it is a real phenomenon. Evidence-based policymaking[19,20] for proposed new energy sources like LENR ensures that the public interest is served for realizing the benefits while also avoiding undeserved support for false claims.

The free market is well established as a force for the public interest. New discoveries like LENR often lead to new technologies that quickly make their way into the market. This did not happen for LENR because of its rejection and its continuing issues of inadequate explanation and lack of reproducibility. Some aspects of the market that are not central to its function—called "market externalities"—may not serve the public interest. Such externalities are also referred to as "market failures." They may require government intervention to protect the public interest. A prime example is the plethora of laws and regulations that were issued by governments around the world, particularly in the 1970s, in response to air, water and land pollution from energy and other industries.

A rational and simple way to apply evidence-based policymaking to the LENR case is to borrow terminology and levels of evidence from the legal field.[21] The relationship between level of evidence and probability has been set forth by Loevinger.[22] Public support decisions can then be made based on the probability that the claim is valid. Because of the importance of LENR to the future of humanity, it is asserted that the proposed policy responses in Table 1 are reasonable.

For a more urgent scenario, including the GCC crisis, the policy response would be to implement a crash program for both the CCE and BRD levels of evidence. If the level of evidence is POE, LENR should be pursued at a higher level than hot fusion in the past.

What, then, is the level of evidence for LENR, and what is the corresponding research support level to best serve the public interest? The scientific evidence for LENR, and the corresponding level of evidence (LPR, POE, CCE, BRD), are a matter of opinion. Rationally, a valid opinion must be informed and based on facts.

To begin with, even at a lower probability (LPR), reinstatement is essential to correct the sociology of science error that occurred when LENR was rejected. The following observations suggest additional levels of evidence for LENR and the corresponding policy responses.

3.1 - Preponderance of Evidence: Fleischmann and Pons Credentials

The first consideration is the scientific qualifications of the chemists—Martin Fleischmann and Stanley Pons—who made the startling claim in 1989.[23] Both had outstanding reputations in the field of electrochemistry, the method they used to achieve LENR. Dr. Pons had been promoted to the chairmanship of the chemistry department at the University of Utah. Dr. Fleischmann was visiting Dr. Pons after retiring from the University of Southampton in England.

Dr. Fleischmann was recognized at the time as one of the world's foremost researchers in the electrochemistry field. In 1986, he was elected to the Royal Society, the top scientific honor in England, based on his contributions to that field.[24] Fleischmann and Pons were extremely well qualified for the work they were doing and knew very well how to perform electrochemical experiments and associated calorimetry to measure excess heat as the primary signature.[8] They conducted these experiments for more than five years to be sure of the results before making the announcement in 1989.

It is asserted, based on Fleischmann and Pons' qualifications, that there is a POE for LENR's existence. The conservative policy response would be at a minimum to support LENR development at the level that hot fusion has been supported for the past 50 years. A more liberal response would be to provide even more support than hot fusion has received in the past.

3.2 - Clear and Convincing Evidence: Early Verifications

Reports of early experimental verifications of Fleischmann

Table 1. Conservative but reasonable policy responses to LENR.

Level of Evidence (LOE)	Probability	Policy Response
Lower Probability (LPR)	<50%	Reinstate; support like other emerging technologies
Preponderance of Evidence (POE)	>50%	Support at a level equivalent to hot fusion
Clear and Convincing Evidence (CCE)	>70%	Support at a higher level than hot fusion
Beyond a Reasonable Doubt (BRD)	>90%	Crash program (like the Manhattan Project)

and Pons' claims are described in books authored by Charles Beaudette in 2002 and Ed Storms in 2007. Bayesian network analysis of early experiment results further supports the original claim.

Beaudette Assertions. In Dr. Charles Beaudette's book[25] he made the point that in normal scientific investigation, confirmation of a new claim leads quickly to widespread acceptance of the discovery. He then described four early and particularly convincing experiments that showed excess heat using electrochemical methods similar to the Fleischmann and Pons design:

– Richard Oriani,[26] Professor Emeritus, University of Minnesota. Performed electrolytic cell experiments in the summer of 1989. Two of the cells produced excess power as shown on a plot of power output as a function of power input. The excess power is indicated on the plot by significant departures of the output above the straight line depicting output equals input power. According to Beaudette, during the 150 minutes of the experiment, about 3.6 watts of excess power were produced.

– Robert Huggins,[27] Professor, Stanford University, California. Began experiments in 1989 in which excess power was measured in terms of percent of input power. In an experiment that lasted 120 minutes, anomalous power was observed from the 40th to the 100th minute. It increased rapidly to a maximum of 56% and then decreased rapidly. The temperature of the cell rose from 11°C to 18°C and then fell back to 11°C during the period of excess power production.

– Melvin Miles,[28] Research Scientist, U.S. Naval Air Weapons Center, China Lake, California. In an electrolytic cell experiment conducted in late 1989, excess power was measured as a ratio of output power to input power. Anomalous power started on Day 7 and reached a ratio of 1.30 from Day 10 to Day 15. The average excess power ratio over 11 days was 1.145. (Not mentioned in Beaudette's book is the fact that Miles' work also showed the correct ratio of helium produced to the amount of heat production, a major step in proving LENR.[29])

– Michael McKubre,[30] Experimentalist, SRI International, Menlo Park, California. Performed longer-term electrochemical cell experiments in 1990 to 1991. One of the cells showed excess heat after 53 days and continuing for 11 days thereafter. During that time, the maximum ratio of output to input power was 1.3.

Storms Findings. Dr. Edmund Storms, who is retired from Los Alamos National Laboratory and is one of the earliest and most prominent LENR researchers, has written two books on the topic that were published in 2007[31] and 2014.[32] In the first book, based on a thorough review of papers in the field from 1989 to 2004, Storms presented (Tables 2, 8, 11) experimental results for three types of LENR signatures. He reported a total of 319 experimental successes using excess heat (184), elemental transmutation (80) and anomalous radiation (55) as the signatures. Over 300 reports of LENR as shown by three kinds of its signatures is very strong evidence of the reality of the phenomenon.

Bayesian Network Analysis (BNA). Rodney Johnson and Michael Melich used Bayesian network analysis (BNA) to evaluate the weight of evidence for LENR.[33] They used the results of previous work by Dennis Cravens and Dennis Letts, who surveyed 167 papers that reported results of electrolytic cell experiments.[34] The survey spanned the years 1989 to 2007. From the results of their study, Cravens and Letts recommended eight papers for application of BNA. Johnson and Melich added the original Fleischmann and Pons report[23] and three arbitrarily selected later papers. Their BNA of the 12 papers resulted in a likelihood ratio of 28 to 1 in favor of LENR. The ratio appeared to grow generally rapidly as more papers were added to the analysis.

It is asserted, based on the early verifications documented by Beaudette and Storms, and by Johnson and Melich (using BNA), that there is at least a CCE level of evidence that LENR is a real phenomenon. In a conservative scenario, the appropriate policy response is to support its research at a higher level than has historically been received by hot fusion. In a more liberal scenario, a crash program should be instituted for LENR development.

3.3 - Beyond a Reasonable Doubt?

The above analysis for the POE and CCE levels of evidence include experiments conducted just up to about 2012. Of course, many experiments have been performed in the years since. An important measure of LENR evidence is the level of continuing interest, an indication of success in the field. Strong continuing interest indicates that LENR's level of evidence may well be beyond a reasonable doubt (BRD).

A prominent example of continued interest is the number of downloads from the LENR-CANR.org website, an online library maintained by Jed Rothwell.[35] It includes 2100 scientific papers and a bibliography of over 4700 books, journal papers and news articles about LENR. Ongoing interest in LENR is indicated by an average of more than 17,000 downloads per month from October 2002 to October 2023. The total visits were more than 7.2 million, and the total downloads were 4.5 million, which is remarkable considering LENR's rejected status.

Another example of continued interest is LENRIA, which was formed in 2015 as an embryo industrial association.[36] LENRIA (LENR Industrial Association) was formed in response to growing interest in the practical possibilities of LENR. In a 2021 update,[37] LENRIA displayed a LENR "ecosystem" with almost 60 entities and organizations in the following categories:

Core Entities (Long Standing)	10
Organizations	7
Government	9
Academia	9
Businesses	16
Publications	7
Total	58

Still another example of ongoing LENR interest is the Anthropocene Institute's "Solid-State Fusion[38] during 2023."[39] It explores several questions, including who is involved in the field, what is known about the science, what is the patent landscape, what can be learned from previous

breakthroughs and what will be the socioeconomic impacts of LENR. Chapter 1 of the document ("Who's Involved in SSF?") references the LENRIA ecosystem and then describes 67 entities and organizations involved in LENR in five categories:

Basic Research Efforts	
Privately Funded Projects	4
Publicly Funded Research	
Multi-Nation	4
U.S.	2
EU	7
Japan	6
Commercial Entities	24
Professional Organizations	5
Investors	3
Media and News Websites	12
Total	67

It may reasonably be argued that the substantial continued interest in LENR is largely because of continued success with the phenomenon. This indirect evidence—on top of the POE and CCE levels up to 2012 described previously—may well indicate that LENR is a real phenomenon beyond a reasonable doubt (BRD).

3.4 - Recap: LENR Evidence and Policy Response

Evidence-based policymaking has long best served the public interest. Based on the level of evidence for LENR, the proposed policy responses are summarized in Table 2.

The levels of evidence asserted here, particularly considering the emerging GCC crisis, show that a crash program is the most appropriate policy response at this time.

4. Policies Required for LENR Deployment

When LENR becomes widely utilized it will certainly be a disruptive technology. Its profound effects will be both direct on the current energy supply chain and indirect on entities closely related to energy.[40] Particularly if LENR energy proves to be deployable in both a centralized configuration (like current power plants) and a distributed manner (like local generators), the entire energy supply chain will be affected. Government intervention may be required to ease the burden of these impacts on elements of the energy industry.

Many elements of society are closely tied to—and dependent upon—the current energy infrastructure. Examples are coal mine and oilfield communities and government entities that rely on taxes on energy facilities. In addition to providing support for energy development, governments may assist private sector and public entities experiencing indirect impacts caused by LENR deployment. Such impacts are not accounted for in market force and are considered another type of market failure. Government intervention to provide assistance is a response to this market failure, similar to laws and regulations for environmental protection and cleanup described above.

Technology assessment (TA),[41,42] is an example methodology for determining social impacts of new technologies that may be used to identify and mitigate the disruptive impacts of LENR energy deployment. TA generally comprises the following elements:

– *Development of the Team.* Includes a multidisciplinary technical team and an over-arching advisory group whose members represent various categories of affected parties.
– *Statement of the Market Failure Problem.* Provides a description of the new energy technology and the limitations of market force. Characterizes LENR as a disruptive technology.
– *Identification of Potential Direct Impacts.* Encompasses impacts on the components of the energy system—supply, transport, storage, consumption.
– *Delineation of Potential Indirect Impacts.* Inventory of various categories of impacted social entities, such as taxing authorities, local governments and workforces.
– *Determination of Policy Options for Impact Mitigation.* Includes existing agencies for services and support. Identifies any "gaps" in coverage and sets forth what's needed.
– *Mitigation Plan Development and Implementation.* The roles and responsibilities of existing (and newly formed, if necessary) agencies are defined. A management structure may be required to deal with gaps and overlaps.

The TA methodology is thus designed to address the consequences of market failure. It was developed more or less concurrently with the plethora of laws and regulations for environmental protection and cleanup in the 1970s. It has been applied successfully to several energy-related issues, including coal-slurry pipelines[43] and large-scale energy development in the western United States.[44]

5. Corollary Policy Considerations

Several factors will have to be considered in LENR policymaking for both research support and mitigation of adverse secondary impacts. These factors include the role of federal agencies, opportunities for the private sector, the problem of inertia of LENR rejection or negative policies and integration of policy changes.

Table 2. Proposed policy responses to LENR, based on the level of evidence.

		Policy Response	
Level of Evidence	**Probability**	**Conservative**	**Urgent (GCC Crisis)**
LPR	<50%	Reinstate, like other emerging technologies	Equivalent to hot fusion
POE	>50%	Equivalent to hot fusion	Higher level than hot fusion
CCE	>70%	Higher level than hot fusion	Crash program
BRD	>90%	Crash program	Crash program

Agency Opportunities, and Responsibilities. Nearly all agencies dealing with energy issues have mission statements for discharging their duties. The agencies are different, of course, for LENR support and mitigation of its disruptive impacts. For example, in the U.S., the Departments of Energy and Defense have interests in energy development and supply. Examples of government entities having responsibilities for impact mitigation are the Environmental Protection Agency and Department of Health and Human Services. Changes in LENR policies represent major opportunities for both types of agencies to fulfill their missions. It may also reasonably be argued that these agencies have a responsibility to incorporate LENR in accomplishing their missions.[45]

Private Sector Opportunities. The main LENR focus of the private sector is on development and deployment rather than dealing with secondary impacts. Because of its lack of acceptable reproducibility, LENR continues to be a high risk for private investment. As noted above, this risk necessitates public support of research in the current early development stage. When LENR becomes viable as an energy source, the private sector can step in for applications and product development. The power of market force will then ensure broad deployment of LENR—and displacement of fossil energy. Private sector investment will be greatly enhanced when negative intellectual property protection policies, particularly those of the U.S. Patent and Trademark Office, are corrected.

Several startups and other small firms are pursuing LENR using empirical approaches because of the lack of an adequate explanation. Large companies, particularly energy consumers (such as firms having large digital server farms), are also supporting LENR R&D. For example, investigations at Texas Tech University, under the leadership of Robert Duncan, are being supported by a confidential sponsor who is prominent in production of both software and hardware. Google is another large firm that has supported LENR research.[46]

Research is also being funded substantially by "angel" investors who don't require a reasonable return on investment but have an interest in human welfare and maintaining the earth's habitability. The Anthropocene Institute, located in Palo Alto, California, for example, has in recent years supported the LENR field in many ways. The 24th International Conference on Cold Fusion (ICCF-24), held in Mountain View, California in 2022, was sponsored by the Institute. Funding is provided for small startup firms, such as Brillouin Energy,[47] that are pursuing LENR as a source of energy. Various other organizations and initiatives are also supported, including the International Society of Condensed Matter Nuclear Science (a LENR professional society).

Overcoming Rejection Inertia. There is no doubt that restoring the legitimacy of LENR and reversing irrational past policies is very challenging. LENR is plagued by a large inertia of negative perception. Despite the rational advantages of interpreting scientific evidence in terms of levels of evidence (POE, CCE, BRD), reversal of negative policies is difficult—even in the face of the emerging GCC crisis. As noted above, it is apparent that LENR's rejection was a failure of sociology of science to function in the public interest.[5,6,48] So too is its continuing failure to correct the problem despite increasingly compelling evidence since the 1989 announcement. Nobel laureate Brian Josephson has noted the irrationality of continued LENR rejection, branding it as "pathological disbelief."[49]

Integration of Policy Changes. In the interest of efficiency and cost effectiveness, LENR-related public policies may be integrated at the national and international level.[50,51]

– *Development and Mitigation*. As support is increased and LENR deployment prospects improve, mitigation planning can proceed with the rate of development.

– *National and International Agency Coordination*. Given the worldwide public interest in realizing the energy benefits of LENR, both international agencies and their counterparts in individual nations must communicate and coordinate efforts to avoid overlap and gaps in coverage.

– *Government and Private Sector Policy Coordination*. As noted, a principal way the government intervenes for the private sector is by sponsoring R&D in the early phases when market force cannot yet be brought to bear. Many companies complement government efforts with their own research programs where, despite the risks, their interest in LENR energy is sufficiently high. Companies and government entities must coordinate their efforts to reduce costs and avoid gaps and overlap in research.

6. Summary and Conclusions

Three centuries of humankind's dependence on fossil fuels for energy threatens the very habitability of the earth. LENR is perhaps the only energy candidate potentially available to displace fossil fuels and their carbon dioxide emissions to deal with the GCC crisis. Government intervention for the development of LENR is essential for the public interest. Based on its level of evidence, a crash program is the most reasonable policy response, particularly with the GCC crisis, for developing and deploying LENR for the future of humankind.

Market force will eventually become the primary impetus for the deployment of cold fusion. Before then, government support is necessary for realizing LENR and securing its benefits. The economic hardships on the energy industry and closely related entities may also need to be mitigated with government assistance. Both cases of government intervention are in recognition of the power as well as the weakness of market force.

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Dr. Thomas Grimshaw became interested in the cold fusion field after a long career in environmental protection and cleanup. He has graduate degrees in geology and public policy. His interests are primarily in cold fusion public policy, supporting investigators and documenting research records. He pursued these interests for more than 14 years at The University of Texas Austin. The assertions in this report were developed during his research for a Master's degree at the LBJ School of Public Affairs and his work at the Center for International Energy and Environmental Policy. Most recently Dr. Grimshaw is continuing his work in the field as President of LENRGY LLC, a cold fusion consulting firm.

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