Near-Term Possibilities for Advancement of LENR

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1. Introduction

The previous article by Katinsky makes the larger economic and societal case for funding of Cold Fusion, or Low Energy Nuclear Reactions (LENR), as part of the fight against diverse damages caused by climate change. That argument might succeed in motivating funding for scientific understanding and commercial exploitation of LENR. If it does, there remain the questions about what to do initially to advance both the understanding of LENR and its widespread practical use. This article discusses potential near-term actions for the overall advancement of LENR. It deals with three actions. The first is what might be done to engender awareness and acceptance of LENR by the scientific community as a legitimate field of scientific inquiry, funding of LENR research by U.S. government agencies and awareness of the field by the general public, especially those concerned with reducing carbon in the atmosphere. The second topic is a potential study of LENR by the U.S. National Academy of Sciences. The last subject is an outline of potential U.S. programs for the understanding, exploitation and utilization of LENR generators. This article is U.S. centric due to two reasons—the author's familiarity with the U.S. system and the size of that system. Acceptance and funding of LENR in the U.S. ought to have a beneficial effect on activities in other countries.

2. Recognition and Funding

Understanding and exploitation are the two most important goals of research and development on LENR. However, both are impeded by the lack of recognition of the field as a legitimate arena for intellectual inquiry, and the lack of support that is a consequence of that shortfall. Hence, the initial effort must be aimed at getting the field recognized and funded. There are a few ways in which that would happen. They are listed in Table 1. The first three possibilities are similar in that they could happen at any time. However, none of them is under the control of people interested in the advancement of LENR. A replication of the 1985 meltdown experiment in the Fleischmann-Pons laboratory with modern instrumentation would attract a lot of attention. However, we have not found a funding source to attempt that replication. The appearance in stores or on the internet of a power generator based on LENR would also get much attention. The product announced recently by Rossi of Leonardo Corporation is not for sale. However, the use of it for production of warm air can be arranged. It is too early to know if there have been any users of the Rossi system, and what is their quantitative experience. The last means to achieve recognition and funding for LENR is the LENRIA Experiment and Analysis Program (LEAP), now in progress with funding from the Anthropocene Institute. The effectiveness of Phase I of that program will be known late in 2019, but the entire program cannot be completed before late 2020.

Table 1. Possibilities for recognition and funding of LENR.

Possibility	When?	Control?
Clear and Accepted Theoretical Explanation	Could be anytime	None
Strong Demonstration Widely Viewed	Could be anytime	None
Strong Public Backing by Billionaire	Could be anytime	None
Replication of the 1985 Meltdown Experiment	Need two years	None. No funding.
LENR Power Generator on the Market	Possibly Leonardo	Little, if any
Multi-Laboratory Replication Experiment	Need two years	In Progress

3. Potential Study by the U.S. National Academy of Sciences (NAS)

Currently, committees of the Congress will not hold hearings on LENR until it has been recognized by the scientific community in the U.S. That recognition could follow from the results of a study of the topic by the NAS. Similarly, government agencies with responsibilities for and related to energy could be influenced by the outcome of a NAS study that thoroughly investigated the voluminous evidence that LENR is a real and promising source of clean energy. Both of these factors are based on empirical information.

In the past, the NAS would do two types of studies. The first is relatively short (a few months) and required about $200K of government agency money. The second was much longer (about two years) and cost roughly $2M, again gov-

ernment agency money. Both were done by an organization built for the purpose, which included appropriate scientific and other personnel. Many of the reports that have resulted from the longer studies are available.[1]

Once the funding is available for a NAS study, there are two initial steps. The first is designation of a chairman for the study, and formation of a committee of experts from the needed disciplines. In the case of LENR, those disciplines would include, at least, solid-state and nuclear physics, electrochemistry, material science, electrical engineering, measurement science and data analysis. The choice of participants is critical, of course. It is best done in a collegial effort by the sponsor of the study and the NAS. Members of the NAS often participate in such studies.

The second early step is development of tasking from the sponsor. It states the desired activities and outcomes. So, an early step in forming a study on the status and promise of LENR would be to provide such tasking. A draft tasking follows. The first two tasks look backward to establish the reality, activities, status and promise of LENR. The next three tasks are forward looking. They deal with potential government programs in the U.S. The final task regards documentation.

Assess the Experimental Reality of LENR

- Review available reports and patents regarding the results of LENR experiments.
- Discuss the status of LENR with scientific and other leaders in the field.
- Summarize and critique the evidence for the production of nuclear products.
- Summarize and critique the evidence for the production of thermal energy.

Review and Summarize Global Efforts to Understand and Exploit LENR

- Review the proceedings of international conferences on LENR.
- Review the national LENR meetings in China, France, Italy, Japan and Russia.
- Summarize and critique current experimental and theoretical research on LENR.
- Summarize and critique current efforts on commercialization of LENR.

Develop and Recommend a National Scientific Research Program to Understand LENR

- Consider the Development of New Instrumentation, Use of the National Synchrotron and Other Facilities, Conduct of Electrochemical Experiments, Conduct of Hot Gas Experiments, Conduct of Plasma Experiments, Conduct of Other Experiments, Material Science and Technology, Data Analysis and Mining, Theoretical Developments and Numerical Simulations.
- Examine the possibility of the National Science Foundation (NSF) leading this program.

Develop and Recommend a National Program for Pre-Competitive Commercialization of LENR

- Consider the Development of Prototypes based on Electrochemical Experiments, Development of Prototypes based on Hot Gas Experiments, Development of Prototypes based on Plasma Experiments, Development of LENR Fuels, Development of Control Systems and Technology-to-Market Projects.
- Examine the possibility of Advanced Research Projects Agency for Energy (ARPA-E) managing this program.

Develop and Recommend a Department of Defense Program for Military Utilization of LENR

- Consider design, testing and production of transportable thermal generators at levels of 10 kW (under 2 m^3) and 100 kW (under 5 m^3), and transportable electrical generators at levels of 5 kW (under 2 m^3) and 50 kW (under 5 m^3).
- Examine the possibility of the Defense Advanced Research Projects Agency (DARPA) managing this program.

Document All Activities and Conclusions Regarding Each of the Above Topics

A study that included these activities and outcomes would involve two major types of activities on the part of the committee members. One would be study of the voluminous published material on LENR. The appendix to this paper contains a listing of most of the major sources of information on LENR. The second committee activity would be to talk to experts on LENR. That could be done by scheduling presentations or in an interview format. The experts could come to the committee, or interact via the internet. It is likely that the committee members would want to visit some active LENR laboratories in the U.S. and, ideally, also abroad.

The impact of NAS studies varies widely. The effects of such studies depend on their content and recommendations, as well as on technological, economic and political factors. So, it is not possible to predict the impact of a LENR study with high confidence. However, it is clear that the world needs sources of clean energy for two major reasons. They are the growing global population, and the increasing *per capita* use of energy as countries develop. Given this need, and growing global concern about the effects of burning fossil fuels on the climate, a NAS study on LENR could get significant and favorable attention in the U.S. and beyond. This last statement indicates that this author believes that the evidence for the reality and promise of LENR is very strong, despite the current lack of understanding and the several challenges of commercializing LENR generators.

4. U.S. National Program on LENR

Whether or not the recommended NAS study were conducted, it is possible to contemplate the organization and activities of programs aimed at scientific understanding, commercial exploitation and military utilization of LENR. Military utilization is included because the U.S. Department of Defense spends enormous amounts of money on energy. Provision of heat and electricity for forward operations and bases is particularly costly. Relatively small and mobile LENR generators, free of the fossil fuel "logistics tail," would be a great advance for the Army and Marine Corps. A national research and development program is outlined and discussed in the rest of this section. It is summarized in Table 2.

The NSF program would have components for the follow-

ing topics:

Development of New Instrumentation
Use of the National Synchrotron and Other Facilities
Conduct of Electrochemical Experiments
Conduct of Hot Gas Experiments
Conduct of Plasma Experiments
Conduct of Other Experiments
Material Science and Technology
Data Analysis and Mining
Theoretical Developments
Numerical Simulations

The ARPA-E Program would have components on the following topics:

Development of Prototypes based on Electrochemical Experiments
Development of Prototypes based on Hot Gas Experiments
Development of Prototypes based on Plasma Experiments
Development of LENR Fuels
Development of Control Systems
Technology-to-Market Projects

The DARPA Program would have components on the following topics:

Production of a Transportable 10 kW (thermal) Generator Module under 2 m^3.
Production of a Transportable 5 kW (electrical) Generator Module under 2 m^3.
Production of a Transportable 100 kW (thermal) Generator System under 5 m^3.
Production of a Transportable 50 kW (electrical) Generator Module under 5 m^3.

This national R&D program on LENR would follow naturally from the NAS study discussed in the last section. However, as already noted, the program could be organized and funded independent of the NAS study. The latter approach would take fewer years.

The program sketched above would fit the missions of the three lead agencies. It would also recognize the realities of organization, funding and management of R&D programs by the U.S. government. It would not be possible to have a single lead organization, what some people call a "czar," for the overall program. That was done for the Manhattan Project during World War II because of the urgency of the situation. Now, even though climate change requires action, the commercialization of LENR would not, by itself, solve the problem of CO_2 in the atmosphere. Put another way, there is not likely to be the national will for a LENR program similar to the Manhattan Project in the very near future. However, if the growing evidence for the effects of global warming becomes (a) widely known and (b) viewed as a crisis, it is conceivable that an immense national project would follow. The negative effects from the massive burning of fossil fuels include increases in sea level, droughts, wildfires, floods, hurricanes and tornados. They might lead to massive migrations within and between countries, which would dwarf current movements of people due to war and famine. Such migrations would have staggering economic effects, both within nations and globally.

Besides involving the three most appropriate U.S. government agencies, the above program would require the expertise of scientists and engineers in the three major sectors where R&D is performed. Universities, government laboratories and companies all have roles to play in all three goals—understanding, exploitation and utilization. Again, there is precedent from the Manhattan Program—specifically, experimental reactor designs built and tested by Enrico Fermi at the University of Chicago. The Los Alamos National Laboratory was organized as the government laboratory for design and overall coordination of the project. E.I. du Pont de Nemours and Company built the Hanford B reactor. All three types of organizations noted above were coordinated by a single lead organization during the wartime Manhattan Project.

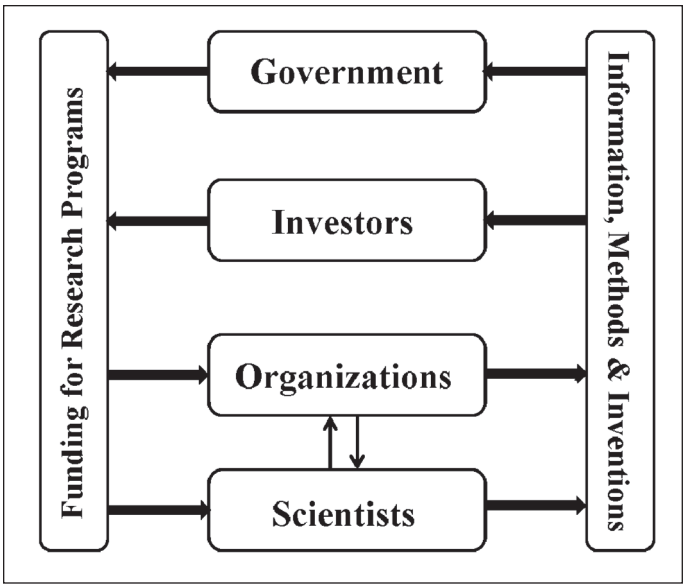
The sizes and durations of the various programs noted in Table 2 are a matter of opinion. Some experienced program managers might prefer programs that are smaller both in funding and duration. Others might want to see larger efforts for longer times. This author has half a century of experience in performing and managing R&D programs. It is his opinion that what is outlined in Table 2 is a reasonable middle ground. Such funding would speed the understanding and use of LENR immensely, compared to the current sparsity of funding. The amount of money involved is not small. The total of the efforts outlined in Table 2 for *five years* sums to $300M. However, that is approximately the amount that the U.S. government now spends on hot fusion research *each year*.[2]

5. Conclusion

The arguments by Katinsky, and concepts for near-term actions based on those arguments, would fix a still broken system for support of LENR. Figure 1 shows the normal flow

Table 2. Organization, goals and programs of a U.S. national R&D program on LENR.

Goals	Scientific Understanding	Commercial Exploitation	Military Utilization
Lead Agencies	NSF	ARPA-E	DARPA
Performer Priorities	1. Universities 2. Government Labs 3. Industry	1. Industry 2. Government Labs 3. Universities	1. Industry 2. Government Labs 3. Universities
Duration of Programs	5 Years	3 Years (Extendable)	3 Years (Extendable)
Average Program Size	$1M/year	$3M/year	$2M/year
Number of Programs	20	10	5
Annual Budget	$20M	$30M	$10M
Total Budget (5 years)	$100M	$150M	$50M



of funding into research, and the resulting flow of information and other results from research. Currently, there appears to be more LENR funding coming from investors than from the U.S. government. LENR has been and will remain an active area of science for many years. It is entirely appropriate that the U.S. government provide research and development funding commensurate with both the scientific challenges and practical potential of LENR as a new source of clean energy.

Comparison of the economic case made by Katinsky in the previous article with what is contemplated in this paper makes the near-term program recommendations, which are envisioned here, look somewhat timid. However, they deal only with the situation in the U.S. Similar funding by other large countries, especially those that contribute heavily to CO_2 emission, would result in a much larger global effort to understand and exploit LENR. Whatever the character and magnitude of LENR programs in other countries, the U.S. programs contemplated in this paper might have a significant favorable impact on the availability of clean energy in the coming decades.

Appendix: Information on LENR

The primary topic of the field came to be called Low Energy Nuclear Reactions (LENR), although there are about twenty other names for the subject.[3] The International Conferences on Condensed Matter Nuclear Science have been a primary global forum for the field over the decades since Fleischmann and Pons announced their ability to produce excess heat energy. The meetings were initially known as the International Conference on Cold Fusion, with the abbreviation of ICCF, which has been retained. Links to the voluminous information presented at ICCF21 in 2018 are at https://www.iccf21.com/. Plans for ICCF22 in 2019 are at https://iscmns.org/iccf22/. Links to the proceedings of many earlier ICCFs are on the web.[4] Proceedings of the recent ICCF conferences are published by the *Journal of Condensed Matter Nuclear Science*.[5] An index to the *JCMNS* volumes is available.[6] Proceedings of the annual meetings of the Japan Cold Fusion Research Society are online.[7] Information on many of the twelve International Workshops on Anomalies in Hydrogen Loaded Metals is also on the internet.[8] The 25th Russian Conference on Cold Nuclear Transmutation and Ball Lightning was held in October 2018.

Several websites are devoted to presenting information on LENR. One has a library with thousands of articles, many of which can be downloaded.[9] There have been months when the average rate of *downloading* papers from that site was about one per minute. A 2009 tally of papers by Rothwell, the keeper of the website, is available.[10] There have been over four million downloads of LENR papers from that one website. Many papers are available from the International Society for Condensed Matter Nuclear Science.[11] Other websites are also useful resources on LENR, including the New Energy Foundation,[12] the New Energy Times,[13] Cold Fusion Times,[14] Cold Fusion Now[15] and the Cold Fusion Community.[16] A summary from 2017 of empirical evidence for the reality and potential of LENR is on the website of this author's consulting company.[17] Note that some sites, and even current papers, continue to use the original name of the field, that is, "cold fusion." Whatever the terminology, a large amount of experimental and theoretical literature on LENR is available, and is open to discussion, criticism, and both experimental and theoretical research.

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