Responsibilities of U.S. Government Agencies for Support of Low Energy Nuclear Reactions

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When LENR was rejected by mainstream science within a year or so after its announcement in 1989, policies of U.S. Government agencies followed suit and became non-supportive. LENR has continued to be researched by many investigators around the world, resulting in increasingly persuasive evidence that its substantial potential benefits will be realized. Agency policies have not changed correspondingly, however, resulting in a large and growing gap between the evidence for LENR and agency policies. Review of the mission and responsibilities of more than 30 Government entities, including the energy committees of the Senate and House of Representative, the President's Executive Office, the Departments of Energy and Defense, NASA, and the Patent and Trade Office, shows that LENR, as a potential emerging energy technology, may contribute to the efforts of agencies to meet their responsibilities. Given LENR's large potential public benefits, and agency mandates to serve the public interest, agencies may in fact have an obligation to pursue LENR as well as prepare for its anticipated adverse secondary impacts. Recommendations are made for agency changes in several policy categories, including energy supply, national defense, research advancement, private-sector interests, environmental protection, and social and economic impacts.

Keywords: Energy Policy. Government Agencies. LENR Policy. LENR Evidence. Outdated Agency Policies. LENR Public Benefit.

1. Introduction

Global needs for energy are increasing relentlessly due to both growing population and increases in per-capita use of energy. Cold fusion is a potential energy source that could help meet these needs. Cold fusion (referred to here as low energy nuclear reactions, LENR) has potential for immense public benefit. The prospects of LENR have improved substantially since it was rejected by mainstream science within a year or so after it was announced in 1989. LENR has continued to be investigated by researchers worldwide as an interesting new phenomenon, for its energy benefits, and in response to its commercial possibilities. Government policies, however, have not kept pace with the changing LENR landscape. A large and growing gap has developed between government policies and LENR prospects for enhancing the public benefit. The gap between LENR science and government policies may be expressed diagrammatically as shown in Figure 1. The consequences of this gap are the failure to realize LENR's benefits, and to prepare proactively to deal effectively with its anticipated adverse secondary impacts as a disruptive new energy technology.

The objective of this paper is to demonstrate the need for changes in U.S. government policies toward LENR. Because U.S. energy policy is decentralized, the focus of the analysis is on the many government agencies having energy responsibilities. The current status and improved prospects of LENR are described, and the opportunities for LENR to help agencies accomplish their missions are delineated. The public interest obligations of agencies to pursue LENR and prepare for its possible adverse secondary impacts are also described.

Approximately 30 agencies in the legislative and executive branches are included. For each agency, the energy policy obligations and activities are described 'in its own words" as represented in readily available sources. These sources include websites, strategic plans, annual reports, operational procedures, and work products such as research reports. More than 50 websites and webpages have been reviewed. A white paper[1] with a more in-depth analysis of agency energy policy serves as an underpinning resource for this paper.

2. Current Status of LENR

The possible benefits of LENR energy are remarkable. Generators based on LENR should be relatively inexpensive. Fuel for them is readily available and virtually inexhaustible. The cost of electricity generated using LENR has been projected to be about 20% of current costs. Experiments have shown that LENR energy would also be environmentally secure, with little or no waste, no hazardous radiation during operation, and no greenhouse gas

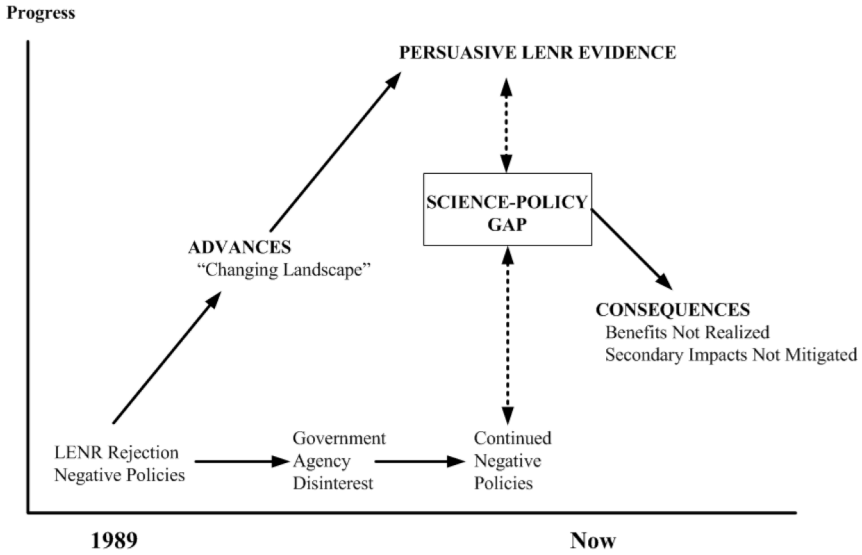

Figure 1. The Growing Gap between LENR Evidence and Outdated Agency Policies

emissions. LENR generators could be deployed in either or both small distributed units for home heating and similar uses or as centralized power plants.

The current status of LENR may be summarized in three major aspects of the field: science, engineering and business. The science of LENR has two parts, experimental and theoretical, that are very different in their state of development. In over a quarter-century since the LENR announcement, excess heat has been observed hundreds of times in very different experiments in laboratories in several countries. The data show that it is possible to produce nuclear reactions at ordinary temperatures. The major experimental problems are production of materials with the properties needed to produce LENR, and related lack of reproducibility and controllability. Although the experimental situation is very solid, the theoretical side of the science remains quite wide open. There are very roughly three dozen theories on the mechanisms behind LENR. However, none of these has been adequately tested, and there is no consensus on the theoretical aspects of LENR.

The engineering side of the field also has two parts, experiments and prototypes of products. The design, fabrication and testing of experimental LENR systems is very well developed. Inspired by over two decades of attacks by critics, and by good laboratory practices by experienced and skilled researchers in the field, some very sophisticated and well-engineered laboratory systems have been built. Their use has also been first-rate in many cases. In contrast, the prototypes revealed by a few of the companies seeking to develop products for a large market are sometimes relatively crude. This may be due to the haste with which these companies are seeking to develop commercial products.

The business of LENR has yet to develop. That is, no one is making money now by marketing of products based on LENR. There are two types of companies involved in the field to very different degrees. Small companies, mostly start-ups, are devoted entirely to the development and commercialization of LENR. These companies vary widely in their size, funding and approaches to making and selling LENR heat or electrical generators. They are working on generators in the kilowatt to one megawatt range. Some large companies are monitoring very closely progress in LENR science, engineering and business. A few are actively involved in the field, but most of the big companies are watching and waiting until it is clear that LENR generators will be adequately controllable, safe, and reliable to receive serious market acceptance.

The maturation of the LENR field is further demonstrated by the formation of an industrial association, LENRIA, in 2015. This association advocates for commercial advancement of the field and serves the global community of interested persons and organizations. It is designed to meet growing needs for (a) provision of information, organization of commercial conferences or expositions, and professional communications to counter opponents and negative propaganda about LENR, and (b) representation of LENR before government bodies, regulators and the public. It was initiated because progress toward a change in the perception of the science and business of LENR is gaining momentum.

Another indicator of the emergence of LENR is the appearance of university programs for research and teaching of the topic. In the past few years, three such programs have been formed. The Sidney Kimmel Institute for Nuclear Renaissance was set up at the University of Missouri in 2012 by Robert Duncan. He moved to Texas Tech University early in 2014, and founded the second LENR-focused academic institute, the Center for Emerging Energy Sciences. The third academic research program, the Division of Condensed Matter Nuclear Reactions at Tohoku University, was instituted in May of 2015 in Sendai, Japan. The three university centers are now addressing basic scientific questions about LENR, rather than developing engineered generators of heat or electricity. However, they can be expected to evolve into more engineering-oriented work as the field further matures.

Yet another indication of the changing status of LENR is the extensive every research that is taking place in many countries. A summary of the efforts in six leading nations for LENR research follows.

A. China. There has been and continues to be substantial scientific interest in LENR in China. The ICCF-9 was hosted at Tsinghua University in Beijing in 2002, and a satellite symposium to ICCF-20 took place in Xiamen University, Fujian province, in 2016. It included presentations from nine laboratories in seven Chinese cities. Some of the work was supported by organizations within the government of China.

B. France. France has also had sustained LENR interests and activities in the years since the 1989 announcement. ICCF-11 was held in France in 2004, and a French LENR researcher serves as the as Editor-in-Chief of the major LENR periodical, the Journal of Condensed Matter Nuclear Science. Currently at least four researchers are active in the LENR field, but no French companies are known to be developing LENR generators for market.

C. India. The history of LENR in India is highly varied. Although 50 scientists were working on LENR initially at the Bhabha Atomic Research Center, work ceased in India for many years. India was the location of ICCF-11 in 2011. A "LENR Specialist Group" has been formed in recent years consisting of four organizations. In 2015 a special section of Current Science, an old and respected Indian journal, was published on LENR. The section has 34 articles on many aspects of LENR by researchers around the globe. Although India has a great need for new and clean energy sources, and its regulations are less restricted than in the US, there are apparently as yet no start up companies seeking to develop LENR generators for either Indian domestic or global markets.

D. Italy. Italy has had a rich history LENR starting from the earliest days of the field. Four of the international LENR conferences , ICCF-2 (1991), ICCF-8 (2000), ICCF-15 (2009) and ICCF-19 (2015) , have been held in Italy. LENR continues to be actively pursued. The major centers of government-supported research have been the Italian National Agency for New Technologies, Energy, and Sustainable Economic Development (ENEA) and in the National Institute of Nuclear Physics (INFN), both in Frascati. A researcher at the University of Siena, whose LENR work dates back to a few months after the 1989 announcement, discovered LENR in nickel-hydrogen systems. He has formed two companies to secure funding for LENR research.

E. Japan. Japan has been and continues to be one of the leading countries in LENR research. Four LENR conferences, ICCF-3 (1992), ICCF-6 (1996), ICCF-12 (2005) and ICCF-20 (2016), have been held in Japan. Meetings of the Japan Cold Fusion Research Society are held regularly. Two companies, both involved with the Condensed Matter Nuclear Reaction Division at Tohoku University in Sendai, have been formed to perform research on and develop products for LENR. Japan has a long history of taking technology developed elsewhere and quickly transitioning it to cost-effective manufacturing. However, in the case of the LENR, the relatively large number of Japanese organizations working on LENR, and the high quality of the researchers, make it possible that Japan will generate seminal scientific advances in the field.

F. Russia. Many Russian institutions have been active in LENR over the entire history of the field. ICCF-13 was held in Sochi in 2007. Russians have also held a long series of national LENR conferences. The 22nd Research Conference on Cold Nuclear Transmutation and Ball Lightning was held in the Fall of 2015. The number and activities of Russian LENR-related companies is difficult to assess, but it is known that some private organizations are working in the field. For example, a poster entitled "The Concept of Propulsion with a LENR Heat Source for Aircraft and Ground Applications" was presented at ICCF-19 in 2015. The authors presented a concept for converting LENR thermal energy into mechanical energy in 500 kW air-jet engine.

In summary, the potential benefits of LENR, combined with its continued research and development worldwide, have significantly improved its prospects. The science, engineering, and business aspects of the field, as well as other developments at universities and in other countries, indicate an increase in its status as a candidate for additional pursuit as an emerging energy technology.

3. Opportunities for LENR in Accomplishing Agency Missions

Energy policy in the U.S. is formulated in a decentralized manner. Opportunities for changes in LENR policy is therefore best accomplished by addressing individual agencies and organizations of the government. The changing landscape of LENR provides opportunities for it to help accomplish the missions of government agencies having energy policy responsibilities. These opportunities provide the basis for closing the gap between LENR prospects and outdated agency policies. The entities of interest have varying types and levels of energy responsibilities. Some are in the legislative branch, but most are in the executive branch of government. More that 30 entities have been included in this paper and are shown in Table 1. For each agency, the background and characteristics are described, the overall mission and responsibilities are set forth, and the general role in energy policymaking is delineated. The importance of emerging energy technologies, in particular, is characterized, and the potential role of LENR as a potential new energy source is described. Previous experience, if there is any, is also covered.

Table 1. Selected U.S. Government Entities with Energy Policy Responsibilities

- Congressional Entities
  - U.S. Senate Committee on Energy and Natural Resources
  - U.S. House of Representatives Committee on Energy and Commerce
  - Congressional Research Service (CRS)
- Entities of the Executive Branch
  - Executive Office
    - Office of Science and Technology Policy (OSTP)
    - National Science and Technology Policy Council (NSTP)
    - President's Council of Advisors on Science and Technology (PCAST)
  - U.S. Department of Energy
    - DOE Headquarters
    - Advanced Research Projects Agency – Energy (ARPA-E)
    - Office of Energy Efficiency and Renewable Energy (EERE)
    - National Renewal Energy Laboratory (NREL)
    - National Laboratories: General
    - Los Alamos National Laboratory (LANL)
  - U.S. Department of Defense
    - DoD Headquarters
    - Energy & Power Community of Interest (COI)
    - Defense Advanced Research Projects Agency (DARPA)
    - Defense Threat Reduction Agency (DTRA)
    - U.S. Navy
      - Office of Naval Research (ONR)
      - Naval Research Laboratory (NRL)
  - U.S. Department of Commerce – Patent and Trade Office (PTO)
  - U.S. National Aeronautics and Space Administration (NASA)
  - U.S. Environmental Protection Agency (EPA)
- Government-Supported Entities
  - National Science Foundation (NSF)
  - National Academies (NAS/NAE/NAM)
- Other Agencies (Seven Having Fewer LENR Opportunities)

3.1 Senate and House Energy Committees

Two Congressional committees, the Senate Energy and Natural Resources (ENR) Committee and the House Energy and Commerce (E&C) Committee, have responsibility for national energy policy at the highest level in the legislative branch. The ENR Committee traces its roots back to 1816. The E&C Committee was created in 1795 and is the oldest standing committee in the House. Both Committees have subcommittees that do much of the detailed policymaking and related work.

The energy mission (jurisdiction) of the two Committees is broad and similar in many respects. The Senate ENR Committee jurisdiction includes energy resources and development, regulation, nuclear energy, surface mining, and federal leasing for fossil energy sources[2]. The scope of its Subcommittee on Energy includes R&D for new technologies, technology commercialization, global climate change, and oversight of the Department of Energy and its National Laboratories. The jurisdiction of the House E&C Committee is also broad and includes national energy policy, energy resources, electrical power production, nuclear energy, energy conservation, and oversight of the Department of Energy and Federal Energy Regulatory Commission[3]. The scope of the Subcommittee on Energy and Power includes energy policy, renewable and nuclear energy, alternative energy sources, synthetic fuels, and energy conservation and efficiency.

The jurisdiction of the Committees includes both traditional energy sources (e.g., oil, gas, coal, and nuclear) and alternative sources (e.g. solar, wind, and geothermal). New and emerging energy technologies are a major component of both Congressional Committees mission as they provide leadership in setting national energy policy. These technologies address new sources of energy both for supply and for reduction of environmental impacts. For example, the Senate's report, Energy 20/20, includes new and emerging technologies in three of its seven sections: Producing More, Clean Energy Technology, and Environmental Responsibility[4]. A Senate energy bill, Energy Policy Modernization Act (EPMCA, S2012) [4], "builds on technological breakthroughs and promises to bring substantial benefits to American families and businesses while protecting the environment." Emerging energy technologies are important in two of the five Titles of EPMCA, specifically Infrastructure and Supply.

With its potential as a new source of abundant, cheap, and clean energy, LENR could play a major role in filling the Committees' mission and meeting their responsibilities. The Committees' broad jurisdictions provide the basis

for adopting policies for LENR development and realization at the highest policymaking level in the nation. It may be feasible, or example, for a member of the Senate or House to take an interest in the potential advantages of LENR and, working with the energy committees, pursue more positive national policies toward LENR. The energy committees' jurisdiction transcends that of individual agencies and could cause movement in new and productive directions for LENR policy.

For example, LENR could be a candidate for inclusion in Producing More along with fossil fuels, alternative fuels, renewables, and nuclear sources. LENR could also be included in the Clean Energy Technology component of the next version of the Energy 20/20 report, both because of its inherent potential for clean energy and its possibility of displacing a portion of fossil fuel based energy. Since LENR could be deployed in either a centralized or dispersed configuration, it could help reduce the burden indicated in Modernizing Energy Delivery Infrastructure component. As a potential clean energy source, LENR could contribute to meeting the Environmental Responsibly component of the Energy 20/20 report. In the Senate ENR Committee's EMPCA, LENR could be a major component of the Act's provisions for both Infrastructure and Supply (Titles II and III). Although the Committees could choose to embrace a policy to consider LENR as a potential energy source that could help meet many of the their objectives, they have apparently not yet chosen to support pursuit of LENR realization.

3.2 Congressional Research Service

The Congressional Research Service (CRS) was created by Congress in 1970 from the former Legislative Reference Service, which had existed since 1946. It is a public policy research entity that works exclusively for the U.S. Senate and House of Representatives. CRS is organizationally within the Library of Congress and has five research divisions[5]. The most relevant for energy-related issues is the Research, Science, and Industry Division, which includes the Energy and Minerals section.

The CRS mission is to provide support to both houses through all stages of the legislative process by providing comprehensive and reliable research and analysis[7]. Because energy policy has become particularly important to Congress since the crises of the 1970s, CRS has produced a number of energy-related reports to inform Congressional action. For example, a recent CRS description of energy in the U.S. addressed renewables, conservation and energy efficiency, and coal, natural gas, and electricity[8]. Other CRS reports have covered energy and water issues, renewable energy, energy storage, loan guarantees, and energy tax policy. Another recent report outlined three major U.S. policy goals since the oil embargoes of the 1970s: secure supply, low costs to meet the needs of a growing economy, and environmental protection[9].

When the Senate or House has addressed R&D for support of emerging technologies, CRS has provided analysis and advisory services. The CRS has therefore had extensive involvement with emerging energy technologies. Research and analyses by the Energy and Minerals section address topics such as emerging technologies, environmental effects of energy production and consumption, and renewable and alternative energy sources[10].

Although CRS would not be expected to conduct policy research on LENR as an emerging technology on its own initiative, it would be well positioned to do so if requested by any Member or by the Senate ENR or House E&C Committee. Given the long-standing commitment to support Congress with comprehensive and unbiased research and analysis, the CRS should be able to provide a balanced assessment of LENR prospects as an energy source, and its potential for impacts as a disruptive new technology. The CRS could, for example, analyze LENR for its potential to contribute to meeting U.S. energy goals as a secure source of supply at low cost and with little or no environmental impact. Government programs that may be applicable to LENR, such as tax policy, loan guarantees, and support for emerging technologies, could also be addressed as CRS research topics.

Congress has not yet chosen to consider LENR within the scope of its energy policymaking, so the CRS has apparently not conducted policy or other research related to LENR and its energy production potential. As a topic for energy policy analysis, LENR could help CRS accomplish its mission. The Energy and Minerals Section of the Resources, Industry and the Environment Division is best positioned to perform a LENR evaluation and policy assessment.

3.3 Executive Office of the President

Along with the U.S. Congress, the President determines energy policy directions at the highest level for the nation. Three entities within the Executive Office support policymaking in science and technology: the Office of Science and Technology Policy (OSTP), the National Science and Technology Council (NSTC), and the President's Council of Advisors on Science and Technology Programs (PCAST). OSTP, NSTC, and PCAST were formed in the Executive Office in 1976, 1993, and 2009, respectively, to provide advice and develop the basis for most aspects of science and technology policymaking.

The OSTP mission is to provide the President and his staff with scientific and technical advice, ensure that Executive Branch policies are based on sound science, and coordinate scientific and technical work in the Executive branch[11]. It's four strategic goals are to maximize U.S. investment in science and technology for the public benefit, facilitate science and technology programs, sustain relationships for science and technology work and policymaking, and maintain staff that provide advice on science and technology aspects of government policies and program.

NSTC is chaired by the President and coordinates science and technology policies among Federal entities that conduct research and development. It includes the OSTP Director, Cabinet Secretaries, and agency heads who are responsible for establishing national goals for Federal science and technology investments. PCAST is co-chaired by the OSTP Director and includes leading U.S. scientists and engineers. It makes policy recommendations regarding science, technology, and innovation that are important to strengthening the U.S. economy[12].

The three entities in the Executive Office address energy policy issues as an important component of their overall science and technology policy advisory function. In their role of energy policy leadership, the President and his advisors in the Executive Office may emphasize emerging technologies that have potential to meet the nation's energy requirements and simultaneously protect human health and the environment. New and emerging energy technologies are naturally a primary focus for science and technology applications.

As a potential new source of energy, LENR could well play a role in achieving the goals of the President and Executive Office in energy policymaking. The President and his advisors could, for example, recognize the immense potential of LENR to help meet the nation's energy needs, and provide executive leadership for policies for LENR development and realization. It does not appear, however, that the Executive Office has yet chosen to pursue policies for LENR development.

3.4 U.S. Department of Energy Headquarters

The U.S. Department of Energy (DOE) is the primary U.S. Agency for dealing with energy topics and policymaking. It was created in 1973 as the twelfth cabinet-level department, and it took responsibility for a framework for a national energy plan, long-term and high-risk energy R&D, energy conservation and regulatory programs, the nuclear weapons program, and energy data collection and analysis[13].

DOE's mission is to ensure America's security and prosperity by addressing energy and related challenges through science and technology[14]. Overall policy within the agency is made at the Headquarters level, and is implemented both at that level and in the various components of the agency. The three main DOE entities, each headed by an Undersecretary reporting to the Secretary, address nuclear security, science and energy, and management and performance of the agency[15].

The DOE strategic plan sets forth three main goals, one for each of the three Undersecretary components[16]. The Science and Energy goal includes three objectives that are particularly significant for new and emerging energy policies: meeting the objectives of the action plan for climate change (and efficient use of the President's "all of the above" energy sources), supporting energy infrastructure, and delivering scientific discoveries and technology innovation.

The DOE plays a major role in supporting national energy policy development as a fundamental reason for its existence. Policies for pursuit of emerging energy technology are very important to DOE's accomplishing its mission. For example, emerging technologies play a vital role in the goal of the Science and Energy Undersecretary with respect to scientific discoveries and technology innovation. They are also key to meeting the goals of addressing climate change, utilizing a mix of energy sources, and developing energy infrastructure.

With its promise as a significant new source of abundant, inexpensive, and clean energy, LENR play an important role in DOE's accomplishing its mission. However, the DOE has been a principal contributor to policies that are not favorable toward pursuit of LENR. For example, an initial report in 1989[17] recommended against special programs or research centers to develop LENR. Although the report was sympathetic toward support for carefully focused and cooperative experiments, little or no support was subsequently forthcoming. A second report in 2004[18] reached conclusions that were similar to those found in the 1989 report. Actions by the DoE after the second report were similar to those after the initial report. No significant LENR programs were funded. DOE continues to decline opportunities for LENR research and potential realization.

If the DOE were to adopt more favorable policies for realization of LENR as an energy source, four components of the agency in particular could play key roles: the Advanced Research Projects Agency–Energy (ARPA-E), the Office of Energy Efficiency and Renewable Energy (EERE) and its laboratory the National Renewable Energy Laboratory (NREL), and its national laboratories, such as Los Alamos National Laboratory (LANL).

3.5 Advanced Research Projects Agency – Energy (ARPA-E)

ARPA-E was authorized in 2007, and its initial projects were funded in 2009. The impetus for creation of the agency was a report by the National Academies, "Rising above the Gathering Storm"[19]. The agency's mission is to catalyze and accelerate the creation of transformational energy technologies by making investments in the early stages of development[20]. ARPA-E advances high-potential high-impact energy technologies that are too early for private-sector investment. The agency focuses on transformational projects that have the potential to radically improve U.S. economics, prosperity, national security, and environmental well-being.

Two approaches are used by ARPA-E to streamline the development process for new technologies[21]. In the first approach, "focused" programs are prepared by the agency's program directors to address specific challenges. The second approach utilizes "open" funding opportunities for energy innovations that are outside the scope of

existing focused programs. ARPA-E has four strategies for bringing early-stage technologies to market: partnerships with private companies, formation of new companies, development with other government entities, and follow-on investment from private investors after ARPA-E awards[22].

By the very nature of its creation, existence, and mission, ARPA-E is a prime entity for researching and realizing emerging energy technologies. As a potential new source of energy, LENR could be a strong candidate for the agency to accomplish its mission. If DOE were to adopt more favorable LENR policies, ARPA-E would be a logical choice to lead the development effort. Support could be provided initially through open solicitations for different LENR approaches. Alternatively, the agency could create a LENR-focused effort under the direction of a program director. ARPA-E has apparently not yet supported LENR to a significant extent.

3.6 Office of Energy Efficiency and Renewable Energy and National Renewable Energy Laboratory

The Office of Energy Efficiency and Renewable Energy (EERE) was formed in 2001 when it was renamed and reorganized from a predecessor organization, the Office of Conservation and Solar Energy. EERE's mission is to create and sustain American leadership in the global transition to a clean energy economy[23]. EERE conducts R&D to make clean energy as affordable and convenient as other energy sources, and seeks to minimize or remove market barriers. Clean energy is pursued to strengthen the economy, reduce dependence on foreign oil, and protect the environment[24]. EERE has five guiding principles for selecting candidates in its pursuit of clean energy technologies: high impact, addition allergy, openness, economic benefit, and proper government role[25].

The National Renewable Energy Laboratory (NREL) is organizationally within EERE and has a similar emphasis on realizing energy from new technologies. NREL's mission is to develop clean energy and energy efficiency technologies and practices, advance related science and engineering, and provide knowledge and innovations to integrate energy systems at all scales[26]. It is the only federal laboratory dedicated to the research, development, commercialization, and deployment of renewable energy and energy efficient technologies. NREL performs analysis to inform policy and investment decisions on energy efficiency and energy technologies throughout the R&D cycle from concept to commercial application and market penetration.

Pursuit of emerging energy technologies is the basic reason for existence for both EERE and NREL. Because LENR’s main raw material source is hydrogen (protium or deuterium), which is relatively abundant and its supply readily renewed, it may qualify as a renewable energy source that could fall under the scope of EERE and NREL. As a potential new energy technology that is not only a clean source (little or no emissions or effluents) but also has promise to displace sources that have major environmental impacts, LENR could well help both the agency and its laboratory accomplish their missions. Neither entity has apparently shown interest in or provided support to LENR development.

3.7 National Laboratories; Los Alamos National Laboratory

The National Laboratories were formed during a period of immense investment prior to World War II and have served as the nation's leaders in scientific innovation for over 60 years. The Labs address large-scale, complex research and development challenges with a multidisciplinary approach and emphasis on translating basic science to innovation and applications[27]. The Laboratories conduct research of the highest caliber, advance U.S. energy independence, promote leadership and clean energy technologies, enhance global security with a safe and reliable nuclear deterrent, help prevent nuclear proliferation, and operate distinctive instrumentation and facilities. The Labs are well positioned and fully capable of realizing the benefits of the emerging energy technologies, and they have done so for many decades.

Los Alamos National Laboratory (LANL) is an excellent example of a National Lab that pursues emerging technologies. It was established in 1943 for the Manhattan Project, in which the atomic bomb was designed and built to achieve victory in World War II. The Laboratory has continued to focus on the U.S. nuclear deterrent, but has also expanded and diversified to solve other emerging national security and energy challenges. It's five major components are: science, technology & engineering; weapons program; global security; capital projects; and operations and business[28].

LANL’s mission is to solve national security challenges through scientific excellence[29]. Its vision is to develop science and technology to protect U.S. and world security. LANL has four stated goals: deliver nuclear security, foster excellence in science and engineering, attract and develop world-class talent, and maintain operational excellence and next-generation facilities and infrastructure. LANL conducts fundamental research in many areas that are relevant to emerging energy technologies, including in particular Applied Physics and Theory, Chemistry, Material Science, Advanced Materials, and High-Performance Computing[30].

LANL searches for energy alternatives, seeks solutions to dependence on oil and coal, and mitigates the effects of climate change. The Laboratory's materials science capabilities enable it to make advances in sustainable energy generation, transmission, and storage. Its work addresses the impacts of climate change and the capture, use, and storage of carbon dioxide.

Should the DOE modify its policies, LENR could be an excellent contributor to LANL and the other National Laboratories in accomplishing their mission. Specifically, LANL's goals to conduct fundamental research (particularly for energy alternatives), seek solutions to dependence on oil and gas, and mitigate climate change could be satisfied through LENR development. LANL did, in fact conduct successful LENR research for some time before the change in DOE policy of support.

3.8 Department of Defense

The U.S. Department of Defense (DoD) is America's oldest and largest government agency. The President is the Commander-in-Chief of the U.S. Armed Forces, and the DoD is headed by the Secretary of Defense. The mission of DoD is to provide the military forces needed to deter war and to protect the security of the U.S.[31] The DoD is one of the largest single consumers of energy in the world. And, much of the energy it uses is the most expensive on per joule basis because of the logistics of hauling fossil fuels to remove deployments. The agency is by far the largest energy consumer in the U.S. government (about 80% of the total)[32]. Therefore, for multiple reasons, the DoD has a very high interest in energy security and cost.

Energy is basic to assuring military capability and the ability to project and sustain U.S. military power[33]. This recognition led to the creation in 2010 of the position of Assistant Secretary of Defense for Operational Energy and Programs[34]. DoD's energy policy, as established by a 2014 DoD Directive[35], is "to enhance military capability, improve energy security, and mitigate costs in its use and management of energy". The Directive states that the DoD will develop and acquire technologies that meet the agency's energy needs and manage risks.

Given the large quantities of energy that DoD consumes, and the increasingly recognized importance of energy in accomplishing its mission, the agency maintains a strong position in developing new and emerging energy technologies. Three entities, described below, provide examples of DoD's emphasis on emerging energy technologies. LENR may have opportunities in helping these entities accomplish their missions.

3.9 DoD Energy & Power Community of Interest

DoD maintains an extensive research capability to develop the technologies needed to accomplish its mission, including assuring energy security. Reliance 21 has been set up as an overarching framework for DoD's Science and Technology planning and coordination[36]. Under Reliance 21, Communities of Interest (COIs) have been established in 17 focus areas to review the alignment of science and technology programs, identify gaps, and help prioritize funding[37].

In response to DoD's strong interest in energy and development of new energy-related technologies, one of the Reliance 21 COIs is Energy and Power (E&P) [38]. The purpose of the E&P COI is to provide technologies to enable intelligent power and energy management to enhance operational effectiveness. The COI critical science and technology capabilities and facilities include three entities in the Army, six in the Navy, and two in the Air Force. The principal areas of focus of the COI are: 1) power generation and energy conversion; 2) energy storage; 3) power control and distribution; 4) thermal transport and control; and 5) electrochemical conversion[39].

Clearly, emerging energy technologies are at the core of the E&P COI purpose and research programs. The COI, or one of its participating entities, could embrace LENR and pursue its development among other emerging energy technologies. LENR may then help the E&P COI (or participating agency) meet its responsibilities, particularly for power generation and distribution.

3.10 Defense Advanced Research Projects Agency

The U.S. Defense Advanced Research Projects Agency (DARPA) was created in February 1958 as a direct response to the launch by the Soviet Union of Sputnik I in 1957 and of the first Intercontinental Ballistic Missile (ICBM) also in that year[40]. DARPA's mission is to "make the pivotal early technology investments that create or prevent technological surprise for U.S. national security"[41]. Stated another way, DARPA's mission is "to identify and pursue high-risk, high-payoff research initiatives across a broad spectrum of science and engineering disciplines and to transform these initiatives into important, radically new, game-changing technologies for U.S. national security"[42].

By making "pivotal" early investments and technologies to prevent strategic surprise, DARPA has made a number of notable achievements. These accomplishments include the conceptual basis for the precursor to the Internet, advances supporting speech recognition, progress in aircraft stealth (low observability) technology, touch-screen displays, and advances in the use of unmanned aerial device vehicles (drones)[43].

Given the increased emphasis of DoD on the role of energy and military capability, DARPA appears to have strong potential interest in emerging energy technologies. For example, the goal of DARPA's Materials for Transduction (MATRIX) program is to extend materials breakthroughs for converting energy between different forms, such as thermal to electric or electric field to magnetic fields[44]. DARPA has the opportunity for future programs that are focused on emerging energy technologies to meet DoD's recognition of the vital importance of energy in accomplishing its mission of deterring war and protecting the security of the US. To the extent that

DARPA focuses on emerging energy technologies, LENR may have opportunities to help the agency meet its responsibilities. DARPA has provided sporadic, but significant support for the pursuit of LENR.

3.11 Defense Threat Reduction Agency

The Defense Threat Reduction Agency (DTRA) works to stop the spread, counter the effects, and prepare for the use of weapons of mass destruction (WMDs)[45]. The agency was created in 1998 from a number of previously existing entities to focus their efforts on terrorism, our nuclear surety, and counter-proliferation[46]. DTRA's mission spans nonproliferation, counter-proliferation, consequence management, countering WMD planning support, and support to the U.S. nuclear deterrent[47]. The agency conducts research and development to detect, destroy, and otherwise neutralize the world's deadliest weapons, such as nerve gas, the plague, and nuclear weapons.

Examination of DTRA's five research thrust areas, WMD sensing, network sciences, and protection, defeat, and securing WMDs, does not indicate an emphasis on energy in general or on emerging energy technologies specifically[48]. Nevertheless, the potential implications for national security, if LENR were to be developed by an adversarial nation, have caused DTRA to engage in the field. Examples of DTRA-supported LENR research are a 2007 report on high energy science and technology that included a LENR panel[49], a 2012 report of a study utilizing palladium and nickel wires[50], and a 2016 report of an investigation of nano-nuclear reactions in condensed matter[51].

3.12 U.S. Navy

The U.S. Navy is one of the three Services of the U.S. DOD. The mission of the Navy is to maintain, train, and equip combat-ready Naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas[52]. The Navy and Marine Corps are significant users of energy within the DOD context, consuming about one-third of the total for the Services[53]. Energy-related topics therefore play a major role in setting the Navy's priorities. For example, Power is one of the four major categories of the Navy's Fiscal Year 2016 Goals and Accomplishments[54]. The other three are People, Platforms, and Partnerships.

The Navy recognizes that "ashore and afloat" its energy efforts cross three functional areas: physical and strategic security, research and development, and policy and doctrine. Its energy strategy is developed using a governance structure called Task Force Energy. It is composed of Working Groups, an Energy Transition Office, and an Executive Steering Committee[55]. The Navy's priority on energy is confirmed by its energy strategy.

Emerging energy technologies are of primary importance to the Navy as it accomplishes its mission of assuring forces capable of winning wars. The Navy's Office of Naval Research, and its Naval Research Laboratory, clearly demonstrate the importance of the emerging energy technologies in accomplishing the Navy's mission.

3.13 U.S. Navy Office of Naval Research

The Office of Naval Research (ONR) was established in 1946 as the U.S. Government's first permanent agency devoted to funding civilian research during peacetime[56]. The ONR manages and funds basic and applied science and advanced technology development through the use of grants and contracts with partners in academia, industry, and government in the U.S. and around the world. The ONR's Naval Science & Technology Strategy identifies the Navy's strategic approach and adjusts the principles of the strategy to current guidance from Naval leaders[57].

The 2015 Science & Technology Strategy includes nine Focus Areas, one of which is Power and Energy[58]. This Focus Area has objectives in three categories: efficient power and energy systems; energy security; and high-energy and pulsed power. The Energy System Technology Evaluation Program (ESTEP), for example, is designed to leverage Navy research in combination with the best of commercial sector advances[59]. ESTEP conducts real-world advanced technology demonstrations to evaluate emerging energy technologies using Navy and Marine Corps facilities as testbeds.

The Power and Energy Focus Area and ESTEP demonstrate the high priority that ONR places on emerging energy technologies to accomplish its energy-related science and technology objectives. LENR may therefore play a significant role in helping ONR accomplish these objectives. ONR funded LENR research from the early years of the field, but no longer supports work on LENR.

3.14 U.S. Naval Research Laboratory

The U.S. Naval Research Laboratory (NRL) was created in 1923. It was instigated by Thomas Edison, who conceived the idea of "a great laboratory"[60]. NRL's mission is to conduct a broadly-based multidisciplinary program of scientific research and advanced technological development directed toward maritime applications of new and improved materials, techniques, equipment, systems, and ocean, atmospheric, and space sciences and related technologies[61]. NRL's research is conducted in a Base Program, which has seven focus areas: 1) battlespace environments; 2) electronics; 3) electromagnetic warfare; 4) information technology; 5) materials and chemistry; 6) space research and space technology; and 7) undersea warfare[62].

NRL has conducted much energy-related research in the past, and it continues to possess the talent and facilities to develop promising emerging energy technologies. To the extent that NRL pursues new energy technologies, LENR may have the opportunity to help the lab accomplish its mission of scientific research and technology

development. The lab, in fact, has a long history of research into LENR phenomena. Evidence cited by NRL for the occurrence of LENR consists of radiation on demand, elemental transmutations, and definitive demonstrations of excess energy[63].

3.15 Patent and Trade Office

The U.S. Patent and Trade Office (PTO) fulfills a mandate of the U.S. Constitution (Article I, Section 8) [64]. It is a component of the U.S. Department of Commerce. The agency was formed in 1836 after a lengthy history of granting patents by predecessor organizations. Its mission is to foster innovation, competitiveness, and economic growth by delivering high-quality and timely examination of patents and trademark applications[65]. The agency advises the President and government agencies on intellectual property (IP) policy protection and enforcement. The PTO guides IP policy and delivers information and education worldwide.

The PTO is a particularly important agency for realizing the benefits of the emerging energy technologies. IP protection for energy devices, technologies, and products are a major part of the PTO's responsibilities. Several energy-related categories have been established for both patents and trademarks.

As a potential new energy technology, LENR technologies should be protected by the PTO, as part of its mission of IP protection. LENR has apparently played a significant role in PTO's procedures for processing patents during the past two decades. In June 1989, apparently in response to the LENR case, the agency initiated a procedure that later became the Sensitive Application Warning (SAWS) Program, which was developed to allow patent examiners to alert agency leadership when a patent might issue on a sensitive matter[66]. Most LENR-related patent applications were not granted as a result of the SAWS program.

However, after an investigation and report regarding SAWS by an entity outside the agency, PTO announced in March 2015 that because the program had been only marginally utilized and provided minimal benefit, it was being retired. The retirement of SAWS may mean that PTO policies regarding LENR as a new energy source may be handled like other energy-related patents without the potential burden of special review.

3.16 National Aeronautics and Space Administration

The U.S. National Aeronautics and Space Administration (NASA) was established in 1958 as a civilian (rather than military) entity to encourage peaceful applications in space science. It is an independent federal agency, that is, organizationally outside the president's cabinet. The mission of the NASA is to drive advances in science, technology, aeronautics, and space exploration[67]. These advances are intended to enhance knowledge, education, innovation, economic vitality, and stewardship of the earth. NASA seeks to ensure that the U.S. remains the world's leader in space exploration and scientific discovery by making advances in aerospace, technology development, and aeronautics. NASA's vision is to reach for new heights and reveal the unknown for the benefit of humankind[68]. The agency's strategic goals are to expand the frontiers of knowledge and ability in space, advance understanding of Earth to improve quality of life, and effectively manage its people.

NASA is one of the nation's premier agencies for developing new and emerging technologies, including energy sources. The agency's energy interests are broad, but three areas are particularly important: space probe propulsion and planetary exploration, aircraft propulsion, and global climate change. As a potential emerging energy technology, LENR may help NASA meet its responsibilities in all three areas. LENR as a potential energy source for space probes and planetary exploration is particularly important to NASA. Potential applications have also been noted for in-space and on-planet sensors and robotics, low earth orbit propulsion, on-planet power, and planetary terraforming. One specific potential application is as a supplement or replacement of radioisotope thermoelectric generators (RTGs).

NASA is also interested in potential aeronautical applications of LENR[69]. Proposed LENR-based propulsion systems include battery, thermoelectric, Sterling engine, and Brayton Cycle approaches. Another aeronautics example is LENR-powered high-altitude, long-endurance aircraft that could be unmanned, and may be used for communications, hurricane tracking, research of high altitudes, and earth observations. NASA’s Earth Observatory System program includes monitoring of the progression and impacts of global climate change. LENR has potential to slow global climate change by displacing sources of carbon dioxide, especially fossil fuels.

Recognizing LENR's potential to help accomplish its mission, NASA has undertaken research in the field going back to the 1989 announcement. Research has taken place at both the Langley and Glenn Research Centers. One early example is a 1989 report on LENR experiments using a hydrogen purifier setup. Although NASA has been one of the foremost agencies engaged in LENR research, these investigations have apparently not been at the forefront of the agency’s research programs. Given the immense potential of LENR to help accomplish its mission, NASA could take more definitive steps, starting with an explicit statement of LENR as a research priority, followed by a well-supported R&D program.

3.17 Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) was created in 1970 in response to increasing public concern about the effects of human activities on the natural environment. It is an independent agency and is not a part of the

President’s cabinet. Its mission is to protect human health and the environment[70]. The agency has listed seven purposes: provide protection from human health and environment risk, reduce risk based on science, enforce environmental laws, assure that U.S. policies consider environmental protection, maintain public access to information for managing risks, assure U.S. leadership in protection of the global environment, and seek diversity, sustainability, and economic productivity. The agency has 13 organizational offices for various environmental protection functions, including water, air, radiation, pollution prevention, solid waste, and emergency response.

Because all phases of the energy cycle have impacts on the environment, EPA has a broad range of energy-related responsibilities and programs. These responsibilities include regulation of fossil energy sources (e.g., coal mines, oil fields and gas operations), as well as energy conversion and consumption activities (e.g., power plants). Emerging energy technologies play a major role for EPA in accomplishing its mission and meeting its responsibilities. For example, EPA's Clean Energy Programs addresses many aspects of the relation between energy and the environment, including combined heat and power, green power, energy and climate, energy efficiency, and corporate climate leadership[71].

LENR has major potential to reduce the use of conventional sources of energy, which cause pollution, and thereby help EPA accomplish its mission to protect human health and the environment. One of the major benefits of LENR as a clean energy source would be its lack of residuals, emissions and effluents, like the residuals produced by fossil energy sources (solid waste, air and water pollutants). To the extent that it could replace fossil sources and their residuals, LENR may therefore play a major role in pollution abatement. Similarly, LENR could support the agency's climate change programs by displacing sources of greenhouse gases from fossil fuel combustion. LENR may even play a role in pollution monitoring, removal, and cleanup as a dispersed source of energy to power monitoring stations. Finally, because it apparently produces energy without significant radiation, LENR may also play a role in protecting the public from radiation from nuclear power sources and their waste products.

EPA has apparently not pursued LENR in the past. Because the agency expends much of its resources in regulating pollution from fossil energy sources and seeking ways to reduce energy consumption, a policy could be instituted to pursue LENR as a means of reducing pollution. LENR R&D may best fit within the scope of EPA’s Clean Energy Programs as a new and promising way to reduce pollution. Such a policy change would help achieve the purposes of risk protection, notably basing risk reduction on good science, and assuring U.S. leadership in global environmental protection as set forth in EPA’s list of its purposes.

3.18 National Science Foundation

The National Science Foundation (NSF) was established in 1950 by an act of Congress. It is an independent Federal agency that does not fall in the jurisdiction of the President's Cabinet. NSF's mission is to promote the progress of science, to advance the national health, prosperity, and welfare, and to secure the national defense[72]. It supports research for all fields of fundamental science and technology, except for the medical sciences. Energy-related research, particularly for new and emerging energy technologies, comprises a critical element for the NSF to achieve its mission, goals, and strategies.

Given its promise as a source of abundant, clean, and inexpensive energy, LENR has the potential to help the NSF achieve its goals to transform the frontiers of science and engineering, to stimulate innovation and to address societal needs. NSF could in fact make LENR a major component of its energy research efforts. LENR research may help the agency promote the progress of science, since much remains to be done to develop an adequate explanation of the phenomenon. It can be argued that realization of LENR-based energy would promote the national welfare as well as help secure the nation’s defense.

LENR research could, for example, become a major clean energy technology, one of NSF’s agency-wide investment areas. Research may also be conducted through NSF support of the U.S. Global Change Research Program[73], given LENR’s potential role as a clean energy source that could partially displace fossil fuels and their carbon dioxide emissions. LENR may also be considered, under current circumstances of the field, within the category of “high-risk, high-payoff” ideas, which NSF suggests in addition to the traditional academic areas. LENR policy updates could be implemented in NSF’s Engineering or its Mathematical and Physical Sciences Directorate, or possibly the Office of International Science and Engineering, given the worldwide research history of the field. NSF apparently has not supported LENR research previously, so policies would need to be instituted to help the agency accomplish its mission.

3.19 National Academies

The National Academies of Science, Engineering, and Medicine ("Academies") were founded by the U.S. Government going back to 1863 to help shape sound policies, inform public opinion, and advance the pursuit of science, engineering, and medicine[74]. Although they are not a part of the Government, the Academies seek to be the nation's preeminent source of high-quality, objective advice in their three areas of expertise. The mission of the Work Units (formerly National Research Council), which perform much of the research for the Academies, is to improve government decision-making and policy, increase public understanding, and promote the acquisition and dissemination of knowledge involving science, engineering, technology, and health[75].

Energy-related research topics are essential the Academies' accomplishing their mission. For example, the Board on Energy and Environmental Systems (BEES) conducts studies to provide independent advice to government and the private sector on energy and the environmental technology and related policy[76]. The BEES directs expert attention to energy supply and demand technologies, environmental consequences of energy activities, systems, and controls for environmental aspects of the energy cycle, and energy-related issues in national security and defense. The Academies are deeply involved in global climate change issues. They have produced reports on several topics, including sea level rise, climate modeling, social stress, and climate stabilization targets. Support for and development of emerging energy technologies are clearly in the mainstream of nearly all of the Academies' energy-related research and policy development efforts.

Given LENR's potential benefit as an emerging technology that has potential as an abundant and environmentally benign source of energy, it could become a major component of the Academies' energy-related policy advisory responsibilities. Undertaking an independent and objective assessment of LENR could, for example, have great potential to help the Academies accomplish their mission and meet the objectives for which they were established. The Academies could assemble a committee of experts, compile and review the current literature and other sources, assess the evidence for LENR, evaluate its promise as an energy source, determine the theoretical and experimental work remaining to be done, and suggest policies for developing LENR and realizing its benefits.

The Academies have apparently not yet chosen to investigate the phenomenon and potential for policy changes. Undertaking a thorough and impartial study could have a major impact on the policies of several government agencies. If the evidence for its existence and potential benefit is deemed sufficient, LENR could become a multi-year and multifaceted policy topic for the Academies. LENR could also be selected as a topic for an Interdisciplinary Research (IDR) team evaluation, particularly given the apparent combined physics and chemistry foundations of the phenomenon. For example, LENR could be included in evaluations of advanced nuclear technologies, as a novel and practical application of nuclear phenomena for the benefit of humankind.

3.20 Other Agencies

Several additional agencies have potential interest in energy issues. However, they are not as salient for the LENR case because emerging energy technologies are not essential to accomplishing their missions or because LENR does not appear to be the type of technology in the profile of their responsibilities. The agencies include the Federal Energy Regulatory Commission, Energy Information Administration, National Energy Technology Laboratory, and member entities of the Intelligence Community, including the Director of National Intelligence, Central Intelligence Agency, Defense Intelligence Agency, and Intelligence Advanced Research Project Activity.

Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) is an independent federal agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas terminals and interstate natural gas pipelines as well as licensing hydropower projects[77]. It was created in 1977 when its predecessor, the Federal Power Commission, was abolished and most of its regulatory mission was inherited by FERC[78]. The mission of FERC is to "assist consumers in obtaining reliable, efficient, and sustainable energy services at a reasonable cost through appropriate regulatory and market means"[79]. FERC's responsibilities are primarily regulatory in nature and are focused on conventional energy sources. Although the agency may address emerging energy technologies in the future as they contribute substantially to the nation's energy supply, it does not appear to be significantly involved in their development. Consequently, LENR may have less opportunity to contribute to FERC's accomplishing its mission than for the other government agencies discussed above.

U.S. DOE Energy Information Administration

The Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy[80]. The agency was created in 1977 as a successor to the Federal Energy Administration. Its mission is to "collect, analyze, and disseminate independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment[81]. " The EIA was set up with independence from other DOE components as well as other government entities[82]. The EIA produces periodic reports (daily to annually) primarily on conventional energy sources, including oil, refined products, natural gas, coal, and electricity[83].

Emerging energy technologies do not appear to be addressed specifically by the EIA. Also, the agency collects energy information rather than supporting or developing new or emerging sources. Consequently, LENR does not appear to have significant opportunity to contribute to EIA's accomplishing its mission.

U.S. DOE National Energy Technology Laboratory

The National Energy Technology Laboratory (NETL) is a U.S. DOE national laboratory that supports the DOE mission to advance the energy security of the U.S. [84] NETL is in DOE's Office of Fossil Energy and is focused primarily on energy from fossil fuels (coal, oil and gas) with a responsibility "to discover, integrate, and mature new technologies and approaches into our nation's energy bloodstream" [85]. NETL's mission is to "discover, integrate,

and mature technology solutions to enhance the nation's energy foundation and protect the environment for future generations"[86]

Although NETL pursues emerging energy technologies, they are primarily related to fossil energy sources. LENR therefore may not be able to help NETL to accomplish its mission as much as it can for other agencies. NETL performs work for the Office of Energy Efficiency and Renewable Energy, but LENR opportunities in helping agencies meet their requirements are likely to be with EERE directly.

U.S. Intelligence Community

The U.S. Intelligence Committee (IC) includes 17 agencies and other entities that work independently and collaboratively to meet the nation's intelligence needs with respect to national security and foreign relations[87]. The IC strives to exhibit three characteristics that are essential to its effectiveness: integration, agility, and exemplifying American values[88]. These values are protection of privacy, respecting human rights, and retaining the trust of the American people. Three of the IC components, the Director of National Intelligence (DNI), the Central Intelligence (CIA), Defense Intelligence Agency (DIA), and the Intelligence Advanced Research Projects Agency (IAPRA), are selected for consideration of potential LENR opportunities.

Director of National Intelligence. Post-9/11 investigations led to passage of the Intelligence Reform and Terrorist Protection Private Prevention Act in 2004, which established the DNI as the head of the IC. The mission of the DNI is to lead intelligence integration and forge an intelligence community that delivers the most insightful intelligence possible[89]. The office of the DNI has set up eight goals, including intelligence integration, information sharing, setting strategic direction, and advancing cutting-edge capabilities[90]. The mission and goals of the DNI do not address energy topics or emerging energy technologies specifically, so LENR may not have opportunities to help the DNI meet its meet the agency's responsibilities.

Central Intelligence Agency (CIA). The CIA was established in 1947 when President Truman signed the National Security Act[91]. It is a principal member of the IC, and the CIA Director reports to the DNI[92]. The CIA's mission is to "preempt threats and further U.S. national security objectives by collecting intelligence that matters, producing objective all-source analysis, conducting effective covert action as directed by the President, and safeguarding the secrets that help keep our Nation safe[93]. The agency is organized into five Directorates to accomplish its mission: Analysis, Digital Innovation, Operations, Science & Technology, and Support, as well as 10 Mission Centers, most of which have a geographic focus[94]. These organizational elements carry out "the intelligence cycle" of collecting, analyzing, and disseminating intelligence information to U.S. Government officials[95].

Examination of the mission and organization of the CIA does not indicate a particular emphasis on energy issues or on emerging energy technologies specifically. LENR may therefore not have significant opportunity to help the CIA accomplish its mission at this time. However, should LENR become an issue of national security, for example, if it is achieved in a nation that is an adversary of the US, LENR may become important to the CIA's mission in the future.

Defense Intelligence Agency (DIA). The DIA is a U.S. DoD combat support agency. It is a central intelligence producer and manager for the Secretary of Defense, Joint Chiefs of Staff, and Unified Combatant Commands[96]. The agency was established by Secretary of Defense Robert McNamara (under President John Kennedy) in 1961[97]. The DIA's mission is to provide intelligence on foreign militaries and operating environments that delivers decision advantage to prevent and decisively win wars[98]. Both the DIA and CIA are members of the IC, but the DIA is a principal source of foreign intelligence to combat-related missions, whereas the CIA is focused on providing intelligence to the President and his Cabinet[99].

Like the CIA, the DIA does not now appear to emphasize energy-related topics or, specifically, emerging energy technologies. LENR may therefore not be able to help the DIA accomplish its mission unless the new energy source were to become a technological threat to the defense of the US.

Intelligence Advanced Research Projects Activity (IARPA). IARPA was established in the Office of the DNI in 2006, and it is therefore a component within the IC. Its paradigm is modeled on the methods at DARPA. IARPA's mission is to invest in high-risk, high-payoff research programs to tackle some of the most difficult challenges of the agencies and disciplines of the IC[100]. Within the IC, IARPA collaborates to ensure its ability to address cross-agency challenges, leverage both operational and R&D expertise across the IC, and coordinate transition strategies. The four research thrusts at IARPA are Analysis, Anticipatory Intelligence, Collection, and Operations. Offices have been set up for each of these three areas[101]. Current Research Areas include computer vision, big data, multilingual speech recognition, satellite image processing, machine learning, geospatial fusion, artificial intelligence, and pattern recognition[102]. During 2016 IARPA launched 12 new multi-year research programs and had over 250 peer-reviewed publications from its funded research[103]. The Heilmeier Questions are applied to proposals and new research programs as they are at DARPA[104]. They include objectives, current approaches, advances in a proposed new approach, how it can be successful, the difference it will make, and the time and cost requirements, as well as mid-term and final progress assessments.

IARPA's research trusts and areas of current research do not appear to emphasize energy topics or emerging energy technologies. However, to the extent that LENR could provide an energy source for IARPA-developed devices, it could in the future potentially contribute to the Activity's accomplishing its mission.

4. Obligations of Agencies for Pursuing LENR and Preparing for Its Impacts

Not only may agencies benefit from LENR contributions in meeting their responsibilities, but they may also have obligations to support it for the public benefit. Government agencies are normally set up to meet a public requirement as determined (or approved) by Congress or the President. An agency mission statement and related descriptions set forth the reasons for existence and how it meets its requirements. Its obligations vary depending on its mission and the type and priorities of its energy policy responsibilities. To the extent that LENR has reasonable potential to contribute to an entity's mission, the entity has an obligation to embrace LENR. General categories of agency obligations are as follows.

E. Energy Source Development

D. National Defense; Energy Security

P. Private Sector Interests; Profit Potential

R. Research Advancement; Increased Scientific Knowledge

V. Environmental Protection; Pollution Abatement

S. Social and Economic Effects

The first four categories are related to LENR's potential as a new source of energy. The last two deal more with secondary impacts ("unintended consequences") on the natural environment and the current energy infrastructure and associated entities, such as energy-focused communities. Many of the categories are overlapping, and an agency may have primary or secondary responsibilities in more than one category. The categories of energy policymaking are described in the following paragraphs, and the agencies having primary and secondary responsibilities are summarized for each category.

E. Energy Source Development

A number of government agencies have responsibilities for assuring an adequate supply of energy at a reasonable cost for the nation. Energy needs are met in the marketplace from a variety of fossil (coal, oil, gas) and alternative energy sources (wind, solar, geothermal, etc.). Agencies have requirements to assure supplies from existing sources and from new and emerging energy technologies and sources. The Senate and House energy committees, for example, have a major focus on adequate supplies among their broad responsibilities. The CRS provides policy development support to the Senate and House as they meet their energy-related responsibilities including development of new sources. The DOE and its components (e.g. HQ, ARPA-E, the national laboratories, EERE) are examples of agencies having supply as primary responsibilities. Because of LENR"s potential as a new energy source, these entities are obligated by their missions to include it in their policies toward emerging energy technologies.

D. National Defense

Energy is increasingly recognized as a central component of the nation's defense system. Like the previous category, this class deals with supply, but with the focus on the need for energy in meeting national defense needs. Energy security and assurance of adequate supplies to the armed forces are among the highest priorities of the DoD and its agencies, such as DARPA, the Energy Community of Interest, and the Navy and other DoD laboratories. Helping insure the nation's defense, including energy, is also part of the mission of the Senate and House of Representatives, the Executive Office, NASA, and the National Academies. LENR's possibilities as an emerging energy technology necessitate these defense-oriented agencies to incorporate LENR in their energy-related policymaking.

P. Private Sector Interests

Government agencies, particularly the U.S. Department of Commerce (DOC), are responsible for supporting and enhancing the interests of the private sector and profit-making companies. The PTO, an agency of the DOC, has as its main concern the support of private interests through its IP (patent and trademark) protection responsibilities. Some agencies also provide assistance to the private sector through "spin-off" benefits that follow from meeting their primary requirements. These agencies include NASA and the research components of the DOE (e.g., ARPA-E, EERE, the National Labs) and the DOD (e.g., DARPA, ONR, NRL, and other defense laboratories). The PTO has an obligation to treat it similar to other emerging energy technologies, particularly for IP protection needs for private-sector development of LENR. Other agencies such as NASA that provide spin-off benefits may also be obligated to pursue LENR for transfer to the private sector.

R. Research Advancement

A number of government entities are charged with advancing scientific knowledge for the public benefit. The National Science Foundation and the three National Academies are foremost in their basic missions for making scientific advances. NASA also rigorously pursues scientific and engineering development to accomplish its mission and serve the general public interest. Likewise, the Executive Office and components of the DOE (ARPA-E, EERE, national laboratories) and the DOD (DARPA, DOD laboratories) seek scientific and engineering advances in order to accomplish their respective primary missions.

Advances in new and emerging energy technologies are a major component of the research profiles of these agencies. LENR is important to the public welfare, both as a potential emerging energy technology and as an interesting scientific phenomenon that could provide unforeseeable benefits in the future. These agencies are therefore obligated to research LENR to meet their responsibilities in advancing scientific knowledge for new sources of energy.

V. Environmental Protection

Protection of the environment has been deemed to be in the public interest going back to the 1970s, during which the majority of relevant legislation was enacted. Emerging technologies have consistently comprised a major part of efforts to protect and enhance the environment. The EPA is the U.S. Government agency having primary responsibility for both protection and cleanup of environmental damage of past activities. Components of the DOE and DOD also have environmental and, particularly, cleanup responsibilities. Research-oriented agencies such as the NSF and National Academies are also engaged in scientific and engineering advances in the environmental field.

Environmental protection and cleanup are especially important in all phases of the energy cycle. Emerging energy technologies contribute to environmental protection both in reducing effluents and emissions and in displacing energy sources having major impacts, such as fossil fuels. Because of LENR's prospects as a new, clean source of energy, the EPA and other agencies are obligated to pursue its development in the public interest.

S. Social and Economic Effects

It appears that no single government agency currently has as its primary mission dealing with social and economic impacts of new and disruptive developments in science and engineering, including emerging energy technologies. However, some agencies, such as EPA and entities in the DOE, have addressed identification and mitigation of adverse secondary impacts of new energy technologies as part of their overall mission. As a potential new energy technology, LENR may be expected to be a disruptive technology for the energy infrastructure, if and when it is broadly deployed. Associated social institutions, such as government entities, from the local to the national level, may also be adversely affected. To the extent that that an agency accepts responsibilities for dealing with the adverse secondary impacts of new energy technologies, the agency is obligated to include LENR as one of the candidates having disruptive impacts.

Agency Obligations Summary

LENR enters the picture for a number of energy policymaking agencies in several policy categories. Not only may agencies benefit from LENR contributions to their accomplishing their missions, but they may also be obligated to embrace LENR to meet their public interest responsibilities. These obligations provide further impetus to close the gap between improved LENR prospects and outdated agency policies toward LENR.

5. Conclusions and Recommendations

Although LENR was rejected soon after its 1989 announcement, it has continued to be investigated extensively in many countries. The results indicate improved prospects that LENR will be commercialized and its benefits realized. The evidence for LENR and its potential benefits has become increasingly persuasive. However, policies of U.S. Government agencies, which were formed during the time that LENR was rejected, have not kept pace with the changing situation. The result is a large and growing gap between the evidence for LENR and agency policies (Figure 1, above). It is recommended that agencies review and change their policies so that LENR, an emerging energy technology with immense potential benefits, has a chance to help accomplish their missions. It is further recommended that agency policy changes be made as an obligation for the public benefit in several policy categories, starting with LENR potential as a new source of energy.

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