Chapter 5

Integrated Policymaking for Realizing Benefits and Mitigating Secondary Impacts of Cold Fusion

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Abstract

The potential benefits of LENR as an energy source have been well understood since its announcement in 1989. Improved prospects of LENR in recent years are indicated by the significant numbers and varied locations of researchers in several countries, a large body of accumulated evidence, advances in development of explanations, and favorable LENR device developments. The changing landscape creates policymaking opportunities for supporting LENR to realize its benefits, planning proactively to deal with anticipated impacts, and integrating the updates as a comprehensive policy program. Policy updates for LENR support may be accomplished in an evidence-based policymaking framework. The level of evidence for LENR indicates that updates should include at least research comparable to other emerging energy technologies. Broad LENR deployment for energy supply is expected to have major secondary impacts as a disruptive technology. Technology assessment is a readily available methodology for developing mitigative measures. The public interest will be served by integrating LENR policies for its development and impact mitigation. For example, policies for secondary impacts can be formulated based on LENR support policies and the pace of its deployment. Updated policies may also be integrated at the national and international level and between the public and private sectors.

Keywords: cold fusion, LENR, energy policy, evidence-based policymaking, secondary impacts, disruptive energy technology, technology assessment

1. Introduction

Cold fusion (widely referred to as low energy nuclear reactions LENR) presents major opportunities to enhance the public interest as a potential new source of cheap and clean energy. Although LENR was rejected by mainstream science within a year or so of its announcement in March 1989, the phenomenon has continued to be extensively researched. LENR's improved prospects in recent years have resulted in a need for updates in LENR policies. Policymaking opportunities are emerging in three main areas—supporting LENR to realize its potential benefits, planning proactively to deal with its anticipated adverse secondary impacts, and integrating the updates in a comprehensive policy program. The objectives of this paper are to:

- Review the changing landscape of LENR
- Describe opportunities for updating policies for support of LENR development
- Delineate potential policies for mitigating adverse secondary impacts
- Analyze opportunities for integrating LENR policies both nationally and internationally
- Summarize the benefits and challenges of achieving updated and integrated policies

The world is in desperate need of new sources of clean and inexpensive energy. If this were not the case, cold fusion would perhaps be just a curiosity in the history of science.

2. The changing landscape of LENR

Improved LENR prospects are indicated by at least four lines of argument—the significant numbers and varied locations of researchers in several countries, the resulting large body of accumulated evidence, advances in development of explanations, and recent favorable events.

2.1. Continued research worldwide

Unlike most claims of new phenomena that are not accepted by mainstream science, LENR research was not discontinued after it was rejected. On the contrary, many investigators have continued to work in the field, resulting in a large body of evidence for LENR reality. For example, at least 50 investigators in nine countries (including the U.S., Italy, Japan, India, Russia, and China) have continued LENR research. An international LENR society (International Society of Condensed Matter Nuclear Science, ISCMNS) was formed several years ago [1], and an affiliated journal dedicated to LENR research reporting (Journal of ISCMNS) is published online quarterly.

International conferences are held in countries around the world every one to 2 years, with a typical attendance of about 200. Twenty conferences (International Conferences on Cold Fusion, ICCFs) have been held since they were begun in 1990. Attendance at the 2015 conference (ICCF-19), which took place in Italy, was nearly 600. The 2016 conference (ICCF-20) was in Sendai, Japan, and the 2018 conference (ICCF-21) is planned for Fort Collins, Colorado (campus of Colorado State University) in 2018 [2]. A substantial community of LENR researchers and other interested parties has emerged. Its size is indicated by the CMNS Google Group, which was formed over 10 years ago and currently has over 300 participants.

Although the U.S. Department of Energy has not provided leadership in LENR research, investigations continued at several other U.S. agencies after the 1989 rejection. For example, the U.S. National Aeronautics and Space Administration (NASA) has conducted research at both the Glenn and Langley research centers [3, 4]. Elements of the U.S. Department of Defense (DoD) have also continued research and related interests. The Defense Intelligence Agency (DIA) assessed "with high confidence that if LENR can produce nuclear-origin energy at room temperatures, this disruptive technology could revolutionize energy production and storage, since nuclear reactions release millions of times more energy per unit mass then do (sic) any known chemical fuel" [5].

Several components of the U.S. Navy have also had active LENR research efforts. The U.S. Naval Research Laboratory (NRL), for example, worked on LENR beginning when the field started in 1989. Other Navy organizations have also pursued LENR research and related activities, including the U.S. Space and Naval Warfare Systems Command (SPAWAR), U.S. Naval Air Weapons Station (China Lake), and the U.S. Naval Postgraduate School.

An industrial association (LENRIA, for LENR Industrial Association) was formed in about 2013 to promote LENR development. LENRIA seeks to "advocate for both scientific study and, especially, commercial advancement of the field" [6]. It envisions a LENR ecosystem consisting of more than 30 R&D concerns, government entities, corporations, private labs, and publications and websites. LENRIA is sponsoring ICCF-21 in June 2018. In early 2017, The Anthropocene Institute published a report that included a list of almost 100 LENR-related entities (another "LENR Ecosystem") in five categories [7]: Makers (37); R&D Organizations (41); Investment Funds (7); Commercial Equipment Suppliers (5); and Non-Profits (6).

2.2. Large and growing body of evidence

The substantial research in LENR has resulted in a large accumulation of evidence for its reality. One indicator of this evidence is a website dedicated to collecting LENR publications (LENR-CANR.org), which has a bibliography of more than 3800 journal papers and related items. As of March 2018, about 4.6 million visits had been made and more than 4.2 million papers had been downloaded [8] from the website.

Storms [9] has documented 380 papers reporting LENR just up to about 2007 as indicated by four signatures—anomalous heat (184 reports), tritium (61), transmutation (80), and radiation (55). Many more reports have been prepared in the subsequent years. Storms and Grimshaw [10] examined the evidence for LENR in relation to published criteria for distinguishing science from pseudoscience by Langmuir [11], Sagan [12], and Shermer [13]. Twenty-seven criteria were compiled, and LENR was examined in relation to each criterion. It was found that the criteria were satisfied, and it was concluded that LENR research is science and not pseudoscience.

2.3. Advances in theory development

Significant progress has also been made in developing an explanation of LENR. Many hypotheses have been advanced, but much remains to be done to converge on a full explanation. Two well-known examples are the hypotheses advanced by Peter Hagelstein of MIT and Edmund Storms, who is retired from Los Alamos National Laboratory.

Hagelstein [14] notes that LENR is indicated by the large amount of energy produced, the absence of expected chemical products, and the presence of expected amounts of new helium-4 in palladium deuteride experiments where LENR is observed. He observes that there appears to be no other conclusion besides a nuclear origin for the observations, but that there is a lack in LENR of the usual radiation signals that are used to study nuclear reactions. Hagelstein's hypothesis includes both conventional and new physics. In palladium deuteride systems reactions occur in vacancies in the lattice. The reactions involve fractionation of a large nuclear quantum combined with a coupling mechanism involving vibration and nuclei. Hagelstein utilizes the fundamental relativistic Hamiltonian in the explanation. The approach thus uses new concepts on a foundation of established physics.

Storms' hypothesis [15] proposes small sites, termed "nuclear active environments" (NAEs), that are located at or close to the surface rather than in the lattice, as is postulated by Hagelstein. These NAEs form in microcracks that are typically caused by stress relief in the material. Hydrogen atoms migrate into the NAEs and form linear structures called "hydrotons." Vibration of the atoms in the hydroton results in nuclear reactions, with release of energy as photons that are absorbed in the lattice. The mechanism of the nuclear reactions in the hydroton has not yet been explained but would almost certainly involve new physics.

2.4. Developments in recent years

The case for LENR is strengthened by several occurrences in the field in the last few years. One of the most significant of these was the emergence of research centers at several universities. The Sidney Kimmel Institute for Nuclear Renaissance (SKINR) was formed at the University of Missouri in 2012 to perform fundamental research aimed at discovery of the mechanisms of the anomalous heat effect (AHE), a term used for LENR. Experiments are performed in four areas—nuclear mechanism, general mechanism, solid state theory, and cathode development (for electrolytic cells) [16]. The Center for Emerging Energy Science (CEES) was founded at Texas Tech University in 2015 to explore critical parameters in the observation of AHE [17]. The intent of its work is to gain fundamental understanding of the LENR mechanisms. A Condensed Matter Nuclear Reactions Division was also recently formed at Tohoku University in Sendai, Japan. Three purposes have been advanced for the Division—fundamental LENR research, development of a new energy generation method, and determination of a new approach for nuclear waste decontamination [18]. This organization sponsored ICCF-20 in Sendai in October 2016.

Further indication that cold fusion potential may be realized is the significant number of LENR-based devices that have been introduced in recent years. One major example is Andrea Rossi's E-Cat (for "energy catalyzer"), which is based on a nickel-hydrogen setup. Several demonstrations of this device were held in 2011, culminating in a multiple-unit test in October 2011. About 2350 kWh of energy was reported for this test [19]. A three-part test of a high-temperature version of Rossi's device (E-Cat HT or "Hot Cat") was subsequently performed [20]. The first part of the test was not considered successful because the reactor melted before meaningful data could be obtained. The second test reportedly produced 195 kWh of energy. The third part was indicated to produce 95 kWh.

Another set of experiments, consisting of two phases, was subsequently performed with a different E-Cat design [21]. These experiments are frequently referred to as the "Lugano test" for the location in Switzerland where they were performed. During the 32-day test, 1.4 MWh of net energy was reported. The experiments also included analyses of the isotopes of in the energy-producing contents of the E-Cat. Observed shifts in the isotope composition before and after the tests were inferred to be the result of nuclear reactions. The large amounts of energy produced, high ratios of output to input power, and changes in isotope content were interpreted as evidence of LENR. It was announced in 2014 that the firm Industrial Heat (IH) had acquired partial rights to Rossi's E-Cat technology [22]. However, the relationship between Rossi and IH did not have a positive outcome and became litigious. A lawsuit between the entities was settled in 2016.

Investigation of devices apparently similar in design to the E-Cat has continued, notably in Russia and China. Parkhomov [23, 24], a retired researcher from Lomonosov Moscow State University, reported experiments performed with two different but related designs. Both devices were configured to approximate the Lugano test of Rossi's E-Cat, but with significant differences, including the method of heat measurement. A principal conclusion was that the devices, described as "similar to (the) high-temperature Rossi heat generator … produce more energy than they consume" above temperatures above about 1100° C. It was also concluded that the second device produced more than 40 kWh of excess energy.

Jiang is a retired researcher affiliated with the Ni-H Research Group at the China Institute of Atomic Energy in Beijing. His reactor design and materials are somewhat similar to those of Parkhomov with a setup approximating the Lugano test [25]. The experiment was apparently performed for over 12 hours, during which 600 W of excess heat was observed for a portion of that time. The reported ratio of the 600 W to the input power of 780 W was 0.77. Jiang concluded that "the origin of excess heat cannot be explained by chemical energy."

JET Energy, Inc. has conducted LENR research with two types of devices called the NANOR and PHUSOR [26], both of which utilize deuterium. The PHUSOR is an aqueous configuration that uses palladium or nickel with the deuterium. The NANOR is non-aqueous and uses nanoscale particles consisting mainly of palladium, zirconium, and nickel. JET Energy maintains close collaboration with the Energy Production and Conversion Group at MIT [27].

Brillouin Energy [28] has developed LENR-based technology for energy production using hydrogen and nickel (or other metal with appropriate properties). The technology is referred to as "Controlled Electron Capture Reaction" (CECR). Hydrogen is brought into contact with nickel, and reactions are stimulated with electromagnetic pulses. The energy is reported to be in the form of heat that is absorbed by the metal and captured for beneficial use. An apparently updated version of the Brillouin approach and technology (HHT™) was recently reported [29].

Although none of these examples has demonstrated a working device having practical applications or commercial production, when considered in aggregate they provide further evidence that LENR may yet fulfill its potential as a source of energy. Overall, a changing landscape for LENR is indicated by the substantial number of researchers, the accumulated body of research, and progress in developing theories. The recent emergence of academic research entities and the proposed LENR energy devices also seem to strengthen the cold fusion case.

Three goals must be achieved for LENR and its benefits to be realized—more consistent reproducibility, fuller explanation of the process, and demonstration of its ability to produce usable amounts of energy. These goals may be achieved with affirmative policies for increased R&D support.

3. Policy updates for LENR support

The first policymaking opportunity resulting from LENR's changing landscape is revision of current policies for LENR support. Updates in these policies may best be accomplished in a framework of evidence-based policymaking (EBP) [30, 31]. The policy options (PO) are:

1. Discontinue research entirely (unlikely given the continuing interest)
2. Business as usual—continued marginalization
3. Reinstatement and development with other emerging energy technologies
4. Enhanced support, perhaps on a par with hot fusion
5. Crash program, possibly like the Manhattan Project during World War II, to realize LENR's benefits.

Selecting the alternative that best serves the public interest may be challenging because of the history and continuing rejection of LENR. Policymaking is further complicated by a need for improved reproducibility and a better explanation of the LENR phenomenon. To deal with these complications, LENR policy may be analyzed and established in terms of level of evidence (LOE) for its existence:

1. Preponderance of evidence (>50% probability)
2. Clear and convincing evidence (>70%)
3. Beyond a reasonable doubt (>90%)

The LOE may be further interpreted for decisions on appropriate policy responses. At least a preponderance of evidence may reasonably be inferred from the large number researchers, the major body of evidence that has been accumulated, and the progress in achieving LENR explanation. Clear and convincing evidence is indicated by the emergence of LENR-dedicated research centers at several universities and by the significant number of proposed devices that purport to produce energy from LENR. When sufficient reproducibility and an adequate explanation are achieved, it may be asserted that the evidence is sufficient to demonstrate LENR beyond a reasonable doubt.

Policy responses to these proposed levels of evidence may also be suggested. If LENR is indicated with a preponderance of evidence, it should be fully reinstated and pursued with other emerging energy technologies. If there is clear and convincing evidence, a higher level

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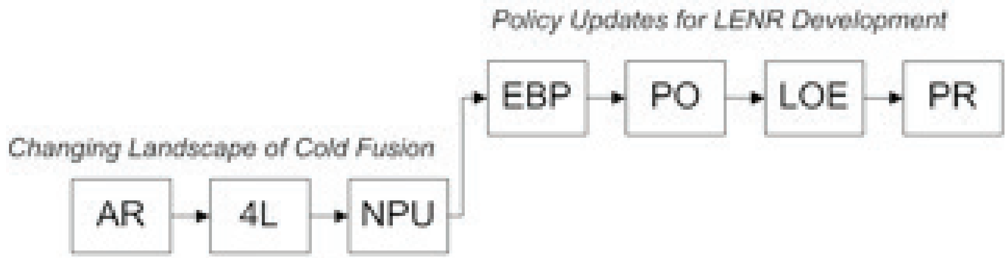

Figure 1. The changing landscape of LENR and resulting need for policy updates for its support. AR—Announcement and rejection (1989); 4 L—Four lines of argument; NPU—Need for policy updates; EBP—Evidence-based policymaking framework; PO—Five policy options; LOE—Level of evidence for LENR; PR—Policy responses (updates).

of support is needed, perhaps comparable to hot fusion support over the past five decades. If LENR is indicated beyond a reasonable doubt, it may be appropriate to institute a crash program similar to the Manhattan Project, which resulted in the atomic bomb in World War II.

In summary, it appears based on the level of evidence that LENR should at a minimum be reinstated and researched fully. It may in fact warrant investigation and development at a level similar to hot fusion research. **Figure 1** shows diagrammatically how the changing landscape of LENR leads to the need for policy updates for its support. The changing landscape began sometime after LENR's 1989 announcement and rejection (AR). The four lines of argument (4 L) for its improved prospects described above lead to a need for policy updates (NPU). The updates are founded on evidence-based policymaking (EBP). The five policy options (PO) are evaluated by the level of evidence (LOE) for LENR existence, leading to the appropriate policy responses (PR)—reinstate and research fully or provide more enhanced support.

4. Policies for mitigating adverse secondary impacts

The second policymaking opportunity resulting from LENR's changing landscape is to address potential adverse secondary impacts with proactive planning. Broad deployment of LENR for energy supply may be expected to have major secondary impacts as a disruptive technology [32, 33]. Direct impacts are anticipated for all phases of the energy chain—supply, transport, storage, and consumption. Indirect impacts will be felt most by the components of society that are closely tied to the energy cycle, such as the affected sectors of the workforce and the communities that rely on energy activities (e.g., coal mining towns).

Technology Assessment (TA) is a mature and well-established method for addressing both direct and indirect secondary impacts and may readily be applied to cold fusion case [34, 35]. The stages of a TA application are generally as follows:

1. Identify impacts
2. Determined affected parties
3. Develop mitigation strategy

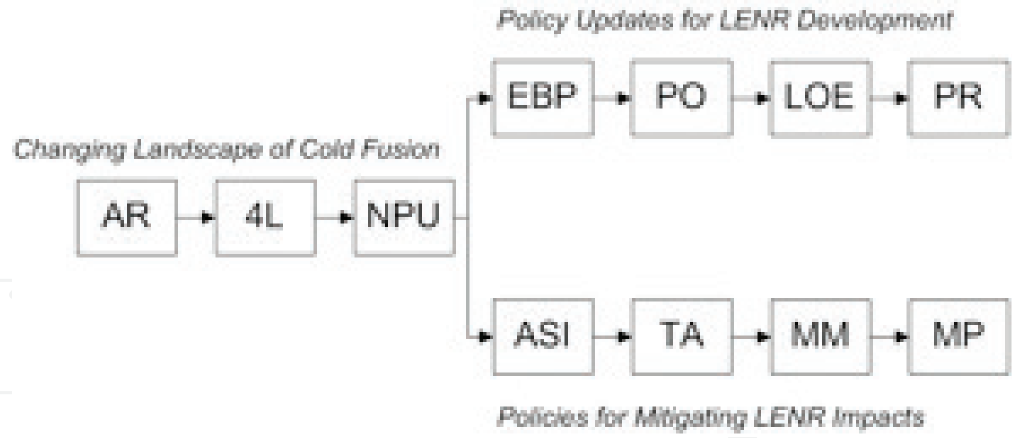

Figure 2. Illustration of need for policies to mitigate adverse secondary impacts resulting from the changing LENR landscape. ASI—Adverse secondary impacts; TA—Technology assessment methodology; MM—Mitigating measures; MP—Overall mitigation plan.

4. Define sources of assistance (e.g., agencies)
5. Engage representatives (e.g., advisory group)
6. Define mitigation measures for both direct and indirect impacts
7. Develop and implement mitigation plan

TA enables proactive planning to mitigate impacts and has ample precedent for application to energy-related issues [36, 37]. **Figure 2** summarizes how the changing LENR landscape leads to the need for policies for mitigating adverse secondary impacts in addition to required policy updates for supporting LENR development. Adverse secondary impacts (ASI) stem from the need for policy updates (NPU) and are addressed by technology assessment methodology (TA). Mitigating measures (MM) are defined, leading to an overall mitigation plan (MP).

5. Opportunities for integrating LENR policies

A third policymaking opportunity for LENR is to integrate the policy actions and updates. For example, policies for mitigation planning for secondary impacts can be coordinated with the pace of LENR development and deployment. Policies can also be integrated among agencies at the national level, between the public and private sectors, and among nations.

5.1. Integration of mitigation planning with LENR development support

As LENR prospects improve as a result of increased support, mitigation planning can be adjusted for the changing imminence and rate of deployment. This adjustment would be necessary to achieve the objectives of proactive planning for mitigation. **Figure 3** shows how the policy response for LENR development (PR) and resulting rate of deployment guides planning for mitigation (GP) as the overall plan (MP) is prepared.

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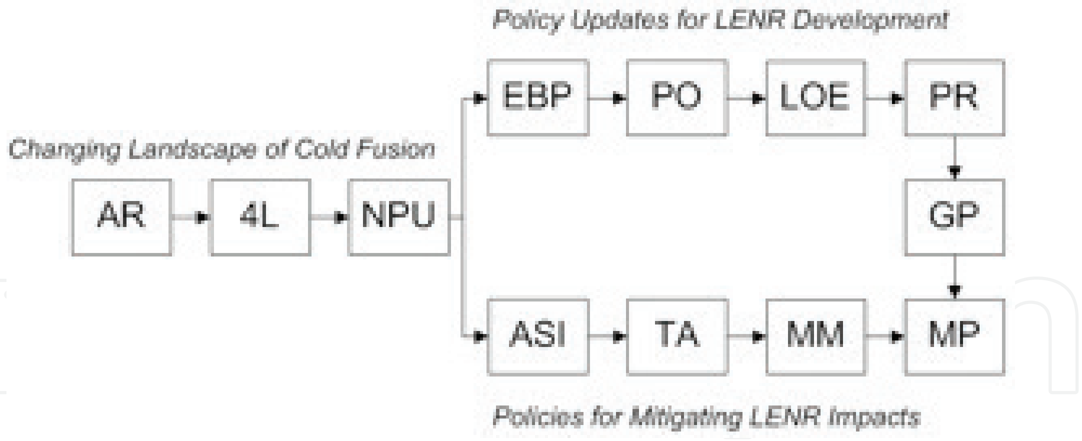

Figure 3. The pace of mitigation planning is guided by policies for LENR development and the resulting rate of its deployment. GP—Guidance for mitigation planning.

5.2. Integration of LENR policies among agencies, nations, and the private sector

A focus on integrated LENR policymaking results in opportunities in several other policy areas. Public agency policy integration (PA) may take place at the local, state, and national levels and requires alignment and effective communication of the policymaking entities within the agencies. Formal arrangements, such as inter-agency agreements, may be used, or integration may be achieved by informal measures, such as regular inter-agency meetings. While these measures have been used to some extent by agencies for various issues in the past, they may become increasingly important as LENR deployment progresses.

LENR development—and dealing with its impacts—may be enhanced with stronger integration between the public and private components of society (PP). For example, LENR may benefit from government policies and measures to address “market failures,” in a similar vein to current laws and regulations for environmental protection. Existing programs, such as small-business research support and provisions for technology transfer from government labs to privately held companies, could increase in importance if the government becomes more active in LENR research. Public-private partnerships (PPPs) may provide another vehicle for supporting LENR development and realization. An improved stance among patent and trademark entities would also substantially enhance efforts in the private sector to realize the benefits of LENR. Opportunities may be found for integrating these policy changes and updates in the public and private aspects of LENR development.

At the international level, programs may be established for supporting LENR research (IN). As LENR reaches the stage of worldwide deployment, bilateral and multi-lateral agreements may be made or updated to enhance its availability. For example, the United Nations may implement programs for making small LENR units available in a dispersed manner in Third World nations. World Bank loans may be made to nations needing support in acquiring LENR technology for the benefit of human health and the environment. The World Trade Organization may consider LENR and its humanitarian benefits for special rulemaking to enhance availability worldwide. Again, opportunities may be found for integration of policy changes or updates among these international entities.

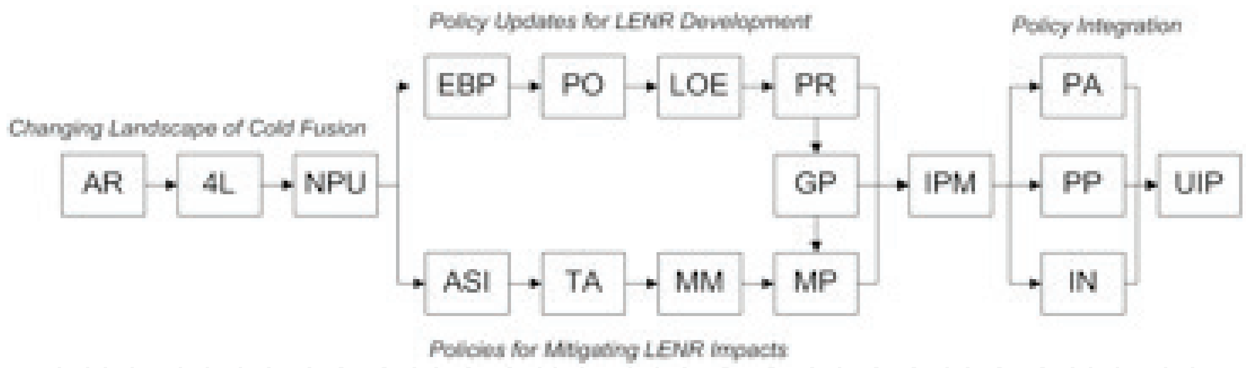

Figure 4. Path to updated and integrated LENR policies. IPM—Integrated policymaking framework; PA—Integration among public agencies; PP—Policy coordination between public and private sectors; IN—Integration among nations at the international level; UIP—Updated and integrated LENR policies.

5.3. Summary path to updated and integrated LENR policies

As policies are updated for LENR support and for mitigating adverse secondary impacts, and as they are integrated at various levels, the public interest will be served for the humanitarian benefits of LENR. **Figure 4** illustrates the full path from the present situation of LENR's changing landscape to the prospective future of fully updated and integrated LENR policies. Integrated policymaking (IPM) for LENR development and mitigating its impacts provides the basis for further updates and integration for public agency (PA), public-private (PP), and international (IN) policymaking. The desired result is fully updated and integrated policies (UIP) for LENR support and impact mitigation as well as among policymaking entities at various levels.

6. Benefits and challenges of LENR policy integration

Achieving integration of LENR policies as updates are accomplished will have substantial public interest benefits. But many challenges must be overcome as well. LENR policy integration will help avoid conflicts and actions that are at cross-purposes among interested parties. Correspondingly, there will be increased efficiency in achieving the policy objectives of the parties as well as increased cost effectiveness where entities have common interests. Policy integration may also achieve improved social equity, with more rational decisions and less influence of purely political considerations.

A principal challenge for policy update and integration is the historical barrier to LENR acceptance after its initial rejection. This barrier seems likely to be surmounted as LENR continues to be investigated and the evidence continues to show that it is real—and that its potential benefits are attainable. Another challenge is the sheer immensity of the expected direct and indirect secondary impacts. Proactive planning to address these impacts will be a major undertaking. The existence of the long-standing and well-established energy policy framework may also present a barrier to effective LENR policies and their integration. This framework includes many conflicting interests and agendas that will have to be considered as policies are updated and integrated.

7. Summary and conclusions

Despite being rejected by mainstream science not long after it was announced, LENR has continued to be pursued in many venues, resulting in improved prospects and the need for policy updates. Updates are needed both for support of LENR development and preparation to mitigate its anticipated adverse secondary impacts. As these updates are accomplished, there are opportunities to integrate the policies to support and realize LENR with mitigation planning for anticipated impacts. There are also policy integration opportunities among public and private entities and at many levels within nations and internationally. The benefits of updating and integrating LENR policies are substantial, but the challenges for doing so are also very large. Opportunities for policy updates and integration may be set forth conceptually, but realization in the "real world" will be much more difficult. Nevertheless, it is clear that the public interest will be served by updating LENR policies and achieving their integration.

Note

The purpose of this Note is to provide attribution for the original source of the paper. It may be deleted if required for this chapter to be included in the book.

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