Public Policy Planning for Broad Deployment of Cold Fusion (LENR) for Energy Production

Thomas W. Grimshaw, PhD, MPAff
Research Fellow, Center for International Energy and Environmental Policy
The University of Texas at Austin, Texas, USA, thomaswgrimshaw@gmail.com

***Abstract* – Cold fusion (LENR) may soon be deployed as a major energy source. Despite its immense public welfare benefit, CF/LENR will likely have adverse secondary impacts that must be addressed through proactive public policy planning. Technology Assessment is a proven method of dealing with the impacts of emerging technologies like CF/LENR.**

***Index Terms* – LENR public policy, technology assessment for LENR impacts, LENR disruptive innovation, LENR impact mitigation.**

I. INTRODUCTION

CF/LENR[A] has the potential for immense benefit as a virtually unlimited and very low cost source of energy. At the same time, it is widely recognized that CF/LENR would be disruptive to the current energy infrastructure, and its broad deployment would have major social impacts. Public policies must be adopted both to support CF/LENR development for the public welfare benefit and to deal with adverse side effects associated with its widespread deployment. Proactive policy planning to mitigate social impacts – the primary topic of this paper – may be most effectively accomplished with the techniques and tools of technology assessment (TA). The prospects of CF/LENR have improved to the point that proactive planning is essential to maximize the public welfare benefit.

II. CONTEXT: POLICY RESPONSE TO IMPACTS OF TECHNOLOGY

Public policies for support of promising new scientific discoveries and technological developments for the public welfare benefit have a long tradition going back to the beginnings of the Industrial Revolution. More recently, progressive policies have also been adopted by many governments to deal with secondary impacts and unintended consequences of technological innovations and their deployment. A prime example of a policy for support of technological advancement is the Manhattan Project, which led to the development of the atomic bomb. Responses to secondary impacts and unintended consequences of technological development and industrial growth are exemplified by the worldwide response for protection of the environment, beginning in the 1960s and 1970s, with major new laws, regulations, and policies. Thus there is ample precedent for proactive public policies to deal with the direct and indirect impacts of widespread CF/LENR deployment.

III. THE CHANGING LANDSCAPE OF CF/LENR

CF/LENR phenomena have been achieved in the laboratory using a variety of methods and materials. The primary signature of the reaction is "excess heat" – energy produced in experiments that cannot be accounted for as the result of chemical reactions. The original CF/LENR claims by Fleischmann and Pons[1] in 1989, as well as most other early experiments, utilized a palladium cathode and heavy water electrolyte in electrochemical cells to produce the effect. Since then, CF/LENR has been achieved with other materials, including nickel and hydrogen in place of palladium and deuterium, and other approaches, such as cells utilizing deuterium gas with powdered palladium.

It is becoming recognized that the initial rejection of CF/LENR by the mainstream scientific community in 1989 and 1990 was almost as controversial as the original claims made by Fleischmann and Pons. Many confirmations of their claims of excess heat have been achieved in the years since 1989. For example, Storms[2] has documented 185 reports of excess heat, 55 reports of anomalous radiation, and 80 reports of elemental transmutation during the period 1989 to 2004. Storms and Grimshaw[3] have demonstrated that CF/LENR investigation is science (rather than to pseudoscience) as measured by three well-recognized sets of criteria set forth by Langmuir, Sagan, and Shermer.

Recent empirical advances, particularly by Andrea Rossi, appear to have improved the prospects for CF/LENR dramatically. Rossi conducted several apparently successful demonstrations of CF/LENR reactions in 2011 in Bologna, Italy[4]. The reactors, referred to by Rossi as "energy catalyzers" ("E-cats"), have been claimed to produce heat energy by exposing powdered nickel to hydrogen gas under pressure. Rossi's

[A] Cold fusion refers to nuclear fusion achieved at relatively low temperatures (compared to the very high temperatures of plasma fusion) with large releases of energy. The term low energy nuclear reactions (LENR) is now preferred by most researchers in the field, but cold fusion continues to be more widely known. The combined acronym CF/LENR is therefore used in this paper.

work is founded on previous experiments by Francesco Piantelli in the mid to late 1990s. A significant feature of the E-cat is its use of the common elements nickel and hydrogen, in contrast to the less common and more expensive palladium and deuterium used in most past CF/LENR experiments.

Demonstrations of "table-top" single units were put on by Rossi in January through early October 2011, leading up to a multiple-reactor demonstration in late October. All of these tests utilized the produced energy for steam generation. The multi-reactor demonstration, which took place in Bologna on October 28, 2011[5], was made with 52 modules (each containing three reactors) mounted on racks in a shipping container. During a 5.5 hour test, apparently with no input power, the total energy produced was claimed to be 2635 kWh, which is equivalent to the energy content of about 72 gallons of gasoline. Rossi discontinued demonstrations after October and now claims to be working on comercialisation of the E-cat technology.

During the same timeframe that Rossi has been developing his E-cat technology, Defkalion Green Technologies (DGT), a firm based in Greece, has been independently developing similar units based on the Rossi reactor design[6]. Rossi and DGT had been working in partnership in the first half of 2011, but Rossi terminated the relationship in August. DGT has continued its work independently to develop its own line of energy catalyzer units, which they call Hyperions, in various sizes for different applications. The units utilize a "single-kernel" and "multi-kernel" (containing nine single kernels) design. DGT issued a press release in January 2012 inviting independent testing of the Hyperion units and is advertising that Hyperion units will be offered for sale in 2012.

Following the apparently successful demonstrations by Rossi and the DGT advances, several more CF/LENR (or related) developments have been announced, including Miley's LENUCO[7], Schwartz's NANOR[8], Brillouin's CECR[9], and Blacklight Power's CIHT[10]. Most of these units, like Rossi's and DGS's, are still empirically-based, indicating that a clear understanding of the underlying mechanism is not yet a certainty.

The steadily growing evidence that CF/LENR is a real phenomenon, and the increasing likelihood that it will be broadly deployed as a major new source of energy, make it essential that proactive public policy planning to deal with its secondary impacts be initiated as soon as possible.

IV. Expected Impacts of Broad CF/LENR Deployment

Besides the clear public welfare benefits of CF/LENR as an energy source, secondary impacts of two types may be anticipated, at least in the short term. The first type is the direct impact on the current energy infrastructure worldwide. These impacts will involve the full life cycle of energy production, transport, and use. The second category consists of the indirect effects on the social systems of countries and their governments throughout the world. Nearly all components of society are affected in some way by energy supply, movement, and consumption. Public policies will be needed to address both types of secondary impacts, and the policies must be well integrated to avoid conflicting or cross purposes.

V. Policies for Disruptive Technology Impacts

Broad deployment of CF/LENR as a major energy source is expected to have a profound impact on the existing world energy infrastructure. The impact of new technologies that rapidly displace existing infrastructure and cause market disruption has been well characterized by Christiansen[11], who used the term "disruptive technologies" ("disruptive innovation" has been found to preferable to disruptive technology because market disruption is a result not so much from a technology as from changing applications of the technology.) CF/LENR has the potential to be deployed in either (or a combination of) a dispersed or centralized manner; that is, as small individual units for homes or other local needs or as large aggregates of units for major applications such as power plants, industrial facilities, or desalination plants. Consequently, all components of the current energy supply, transport and use infrastructure are likely to experience major adjustments. Policies will have to be developed for each component of the energy infrastructure to help deal with these adjustments.

VI. Policies for Broad Social Impacts

The indirect impacts of CF/LENR deployment on social systems may be expected to be large and far-reaching. Areas of major potential impact include tax revenues, workforce employment stresses, changes in energy-related community functions, income redistribution, geopolitical shifts, and many others. Fortunately, methods have been developed to identify these areas of impact, the level or degree of effects, and opportunities for proactive policies to deal with the impacts.

Technology Assessment (TA) is one of the most effective methods of identifying impacts of technology on society and developing policies to deal with the impacts[12]. TA was developed in the same timeframe in the 1960s and 1970s as methods for determining environmental impacts of many types of human activities. The majority of descriptions of TA methodologies include the following elements:

- Statement of the Problem
- Description of the Technology
- Delineation of Parties at Interest
- Identification of Potential Direct and Indirect Impacts
- Description of the Policy-Making Infrastructure

- Evaluation of Type and Degree of Impacts
- Delineation of Policy Options for Dealing with Impacts
- Conclusions and Recommendations for Policy Options
- Implementation of Selected Policy Options

Two previous energy-related TAs may be referenced as approaches that may be used in a CF/LENR TA. The first example, "A Technology Assessment of Western Energy Resource Development"[13] addressed broad development of six energy resources (crude oil, natural gas, coal, uranium, oil shale, and geothermal) in eight western states (MT, ND, SD, WY, UT, CO, NM, and AZ) with respect to eight categories of impacts:

- Air Quality. Including ambient air impacts on growth communities, background pollution levels, and effects on visibility (for example)
- Water Quality. Including effects of mining and in-situ resource recover, pollution from holding ponds, and control of salinity (for example)
- Water Availability. Including water shortages in the Colorado River Basin, water rights conflicts in the Upper Missouri River Basin, and impacts on irrigated agriculture (for example)
- Transportation. Including inadequate transportation capacity and impacts of train traffic and electric power transmission lines (for example)
- Land Use. Including land disturbance, ecological damage, and conflicts over land use (for example)
- Energy Facility Siting. Including regulatory complexity and siting uncertainties
- Capital Availability. Including economic risks of energy development and insufficient competition among energy companies (for example)
- Growth Management and Housing. Including, for example, imbalance of public resources and expenditures, public sector assistance, and inadequate cooperation between the public and private sectors (for example)

For each of the eight categories, policy alternatives were identified, evaluated, and compared.

The second energy-related TA example[14], a study of broad deployment of coal slurry pipelines in the U.S., dealt with the following issues:

- Comparative description of coal slurry pipelines and their competitors, coal unit trains
- Coal transportation market and costs
- Economic impacts of coal slurry pipelines (including comparison with unit trains)
- Environmental impacts (water supply, use and reuse; air emissions; ecological disruption)
- Energy and material requirements
- Occupational, safety and health
- Construction impacts and community disruption
- Legal and regulatory analysis (transportation regulation, water law, environmental law, eminent domain)
- Capital investment, employment, and tax considerations

Although the western US energy development and the coal slurry pipeline examples dealt with somewhat different technologies and concerns, they demonstrate that the TA method has the ability to address a full range of issues and the power to provide solutions for the expected secondary impacts of CF/LENR deployment as a major new source of energy.

VII. Technology Assessment for CF/LENR Deployment

The degree of market success and rate of deployment of CF/LENR will determine how the TA methodology will be applied to address its secondary impacts. The TA will therefore be accomplished in phases so that the timing and level of effort can be as well matched as possible to the type and degree of CF/LENR deployment and its impacts. The Phase 1 tasks will consist of the work required to develop a policy strategy and step-by-step plan that will then be implemented in Phase 2. The second phase will comprise the policies, programs and activities required to mitigate the identified adverse consequences. The Phase 1 and 2 tasks, described below, will be conducted in succession, with overlapping periods of performance where possible. As each task is performed, the scope of subsequent tasks will be fine-tuned to reflect current findings as well as the evolving success and rate of deployment of CF/LENR.

A. Characterize CF/LENR as a Revolutionary Energy Technology

The first task of Phase 1 will be to describe CF/LENR technology in sufficient detail to permit assessment of the type and level of its impact on the full cycle of current energy production, transport, and use. Much is still unknown about CF/LENR and its theoretical and usability underpinnings, which will strongly affect the rate at which it is accepted and deployed. Information on CF/LENR technologies and its usefulness for energy supply will be assembled from as many sources as possible. Information gathering will focus initially on the Web, but will also include readily available published papers, conference proceedings, and other traditional publication sources.

A preliminary synopsis of the CF/LENR status and activities will be performed based on initial information gathering. Knowledgeable experts, both in energy impact analysis broadly and CF/LENR status and prospects specifically, will then be interviewed. CF/LENR conferences and programs will be attended to present papers, attend sessions, and network with conference attendees. A Task A report will be prepared that not only summarizes the status of CF/LENR development, but also evaluates its potential secondary impacts. Salient features of CF/LENR that will determine its impacts will be detailed, including the following:

- Low cost of energy production in relation to other sources
- Flexibility for deployment in many energy supply applications, including heat and electrical power generation
- High operability and maintainability of both central and dispersed units
- Ability to be deployed as a combination of large central and small dispersed energy-producing units, with flexibility in sizing to meet the full range of energy applications
- Ease of operation and long times between required refuelling
- Abundant input resources, such as hydrogen and nickel or deuterium and palladium

Nagel[15] has listed no fewer than 40 potential advantages and impacts of CF/LENR deployment for thermal and electrical power.

B. Finalize Impact Assessment and Mitigation Methodology

After the status and potential secondary impacts of CF/LENR are assessed, the TA methodology can be defined more completely for application in subsequent tasks. A literature survey of applicable methods for technology-related policy planning will be conducted, and successful cases of proactive energy planning in the past will be identified and evaluated, starting with the two energy-related TA examples described above. The relevant CF/LENR features identified in Task A above will be addressed in the TA literature review and methodology assessment. The TA methodology will focus on opportunities for impact mitigation as well as identifying the potential adverse effects. A Task B report will be prepared as a complement to the Task A report for selection of the TA methodology for the specific CF/LENR case.

C. Form Advisory Group and Assemble Project Team

Given the broad range of potential impacts of CF/LENR deployment on many diverse social systems, an interdisciplinary Project Team will be required to perform the TA. Similarly, senior oversight and direction of the TA will need to be provided by a multidisciplinary Advisory Group. As the salient CF/LENR characteristics are described and the TA methodology is finalized in Tasks A and B, the Advisory Group and Project Team will be established. A draft Phase 1 Project Plan will also be prepared. An initial meeting of the Advisory Group will be convened not only to establish overall project guidance, but also to identify candidate members for the Project Team. These Team members will then be interviewed for participation in the TA project.

Based on the outcome of the Advisory Group meeting and on initial discussions with Project Team members, the draft Phase 1 Project Plan will be updated. The draft Plan will be circulated among the Advisory Group and Project Team members for review and comment. A kickoff meeting with the Project Team for will then be conducted for teambuilding and to receive additional input on the Project Plan. Based on suggestions and feedback from the Advisory Group and Project Team, the Phase 1 Project Plan will again be revised as required. The Advisory Group and Project Team will be organized to maximize opportunities for cross-disciplinary exchanges, issue analysis, and mitigation strategy development.

D. Define Direct Impacts on Energy Production Infrastructure

Because CF/LENR has strong potential to emerge as a disruptive new energy innovation, it is essential that the entities most directly impacted be clearly identified. Furthermore, CF/LENR may be deployed in either a centralized or dispersed manner, so different components of the energy infrastructure may be affected differently.

The results of the analysis in Task A above will be used to identify (for the complete chain of energy production, transportation, and point of sale) the organizations – particularly energy companies and utilities – that will be most directly impacted. The rate of market penetration of CF/LENR units into the various energy production sectors will be evaluated, including constraining factors such as manufacture of components. Relying on input and guidance from the Advisory Group, knowledgeable experts and stakeholders in the various energy sectors will be identified and interviewed.

The most appropriate entities, such as trade organizations, will also be interviewed to gain perspectives on the potential impacts of – and responses to – CF/LENR deployment, and the areas and sectors where it will have the greatest impact will be identified. The opportunities for existing energy organizations to respond to CF/LENR deployment, as well as their capacities to respond, will be assessed, and a suite of potential mitigative measures will be developed. A Task D report will then be prepared with identification of CF/LENR deployment impacts, the organizations affected, their abilities to respond, and preliminary mitigative measures.

E. Evaluate Indirect Impacts

Identifying and mitigating potential adverse indirect impacts of CF/LENR deployment broadly on social systems is a principal focus of proactive policy planning using TA methods. Advance planning for such indirect impacts may be of greater importance than for the direct effects because of the potential limited ability of the affected populations and entities to discern the emerging impacts or to deal with them adequately when they occur.

Entities that will be most impacted indirectly will be identified first by referencing the directly affected organizations defined in Task D above. The impacts on directly affected entities will determine which social systems will receive the greatest indirect effects. Categories will be developed for entities having similar profiles and types of expected indirect impacts, such as communities, businesses, workforces, governments, and financial institutions. The types and levels of expected impacts will be defined for each category utilizing scenarios of CF/LENR deployment, such as rate of market penetration.

Candidate representative stakeholders for each category will then be identified and interviewed for perspectives on impacts and approaches to mitigation. For the categories of the most highly impacted entities, conceptual approaches, methods, and available tools for mitigation of adverse impacts will be identified in more detail. A Task E report on the findings of indirect impacts – and potential mitigation strategies – of broad CF/LENR deployment will be prepared.

F. Finalize Mitigative Strategies

As the direct and indirect impacts of CF/LENR deployment are clearly understood, appropriate mitigative measures will be expanded upon. The preliminary lists of conceptual mitigative approaches prepared in Tasks D and E will be reviewed, and a draft mitigative measures plan addressing both types of direct and indirect impacts will be prepared. Interviews of knowledgeable stakeholders will again be conducted (relying as much as possible on previously interviewed individuals) for additional ideas for mitigation and refinement of strategies. Mitigation of direct impacts will consider such measures as assistance with transition to energy production with CF/LENR technology. Indirect impact mitigation is expected to include actions such as workforce re-education, community assistance, and public information programs.

Existing support organizations, such as employment agencies, workforce training organizations, and community assistance programs, that may be involved in mitigation activities, will be identified, and the mitigative measures plan will be reviewed for involvement of each organization. The final mitigation strategies will be documented in a Task F report.

G. Prepare Phase 1 Report and Phase 2 Plan

An overall impact assessment and mitigation strategy report will be prepared at the conclusion of Phase 1. The reports from Tasks A to F will be integrated and synthesized, and a draft plan for Phase 2 will be developed. The Phase 1 report is expected to be organized similarly to the topics covered in the task reports. The draft Phase 2 plan will include specific activities and timelines as well as proposed project participants and target audiences. Focus will be placed on key managers and staff in the organizations that will be most affected by CF/LENR deployment – and that will be in position to implement mitigation strategies.

Although the details of Phase 2 cannot be foreseen in advance, it is anticipated that assistance will be needed for each of the impacted entities and organizations to plan for and deal with the impacts specifically for their areas of responsibility. As noted, focus will be placed on working with existing support organizations and infrastructure to help ensure that effective mitigations plans are prepared and implemented.

It is anticipated that Phase 2 will begin with a series of targeted workshops to communicate the prospective CF/LENR deployment to the organizations and entities that will be most impacted. The workshops will focus on the need for – and methods of – mitigating direct and indirect impacts and will introduce the approaches proposed in the draft Phase 2 plan as the basis for receiving feedback and guidance for proactive policy development. The initial complement of participants will be identified by the Advisory Group and Project Team. Based on feedback and lessons learned from the workshops, the Phase 2 plan will be finalized and implemented. Emphasis will be placed on including workshop participants who may eventually be responsible for implementing the identified proactive measures.

H. Project Management

The CF/LENR TA must be conducted in accordance with accepted project management practices, such as the methods of the Project Management Institute[16]. Details of management of the TA will be spelled out in the Phase 1 Project Plan that will be developed in Task C. Phase 1 of the project is expected to take approximately one year to complete. The timeframe of Phase 2 will be included in the Phase 2 plan.

VIII. Conclusion: Necessity for Proactive Policy Planning

Despite its initial – and problematic – rejection, CF/LENR has continued to be investigated, resulting in many confirmations and verifications. Although issues remain, such as inadequate theoretical underpinnings and need for greater acceptance by both the scientific establishment and the general public, CF/LENR now shows promise of becoming a major contributor to the world’s supply of energy in the near future. The direct and indirect impacts are likely to be very large and will require major shifts in public policy. Proactive planning for effective and responsive policies is essential and should begin as soon as possible. The problem is well understood, effective methods have been identified and adapted, potential participants have been targeted, and the specific tasks required have been set forth. All that remains is for the “tipping point” to be reached for broad CF/LENR deployment and widespread acceptance.

IX. Public Policy Analysis at The University of Texas at Austin

Staff, resources, and facilities for proactive public policy planning for CF/LENR are primarily in two organizations at The University of Texas at Austin – the

Center for International Energy and Environmental Policy (CIEEP) and the Lyndon B Johnson School of Public Affairs.

CIEEP joins the capabilities of the LBJ School with those of the College of Engineering and the Jackson School of Geosciences. As the University's first center dedicated to energy and environmental policy, CIEEP seeks to inform the policymaking process with the best scientific and engineering expertise and strives to become the academic leader in integrated, science and engineering-based energy research and education. CIEEP provides interdisciplinary assessments of current and emerging global energy and environmental issues and develops policy options for dealing with the issues at the global, national, and local scales.

Since its founding in 1970, the LBJ School has built a proud tradition of public service and cutting-edge research on the most important public policy challenges of our time. LBJ School's mission is to develop leaders and ideas that will help the nation and the international community address critical public policy challenges in an ever increasingly interconnected and interdependent world. A broad array of academic and research programs has contributed to the LJB School's reputation in energy policy, international affairs and trade, technology policy, leadership, economics, energy and environment, and public and nonprofit management.

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