Preface

This Preface has five main sections:

Background. The development of the field, which was originally called “cold fusion” and is now known by various other names, is discussed here.

Terminology - What name do you give this discovery? A review is given of the diversity of terms and motivations for their use to describe the field.

The International Conferences on Cold Fusion – A statistical history. This conference series has been the primary venue for exchange of scientific information in the field. Locations, dates, and the numbers of attendees, countries represented, papers, and authors, are tabulated along with other data and comments.

Strategies for ICCF-14 and These Proceedings. A deliberate strategy was developed to set the location and the agenda for ICCF-14. This section gives an overview of the main parts of the conference, and provides the motivations for why they were scheduled as they were. It also explains the character of introductions written specifically for each section of these proceedings in order to make them intelligible to a wider audience.

Summary of the Field. Presents an overall summary of the field, organized by what is not known and what is known.

Background

Truly unexpected experimental results, which seem beyond explanation by well-developed physical theory, became increasingly rare at the end of the twentieth century. After World War II, physical scientists sought, with significant success, to work out the implications of electromagetism, relativity, nuclear and elementary particle processes, and even superconductivity, all within the context of the various flavors of quantum mechanics.

The last time such confidence had existed in natural science was around 1870. By 1870 the crisis of Newtonian mechanics was seemingly resolved with the theoretical prediction of a new planet, its orbit and mass, and the subsequent observation of Neptune. The integration of electricity and magnetism by Maxwell in the 1860s set the foundation for all subsequent thinking about this class of effects. This confidence began eroding in the mid-1870s. The experimentally driven revolutions of the last twenty-five years of the nineteenth century, notably “x-rays”, “radioactivity”, and “charged corpuscles” (electrons), delivered to the twentieth century science a wealth of change that seemed mostly under control by the 1980’s.

Thus, two unexpected announcements in the late 1980’s, high temperature superconductivity and “cold fusion”, echoed the disruptive experiments of the end of the nineteenth century. Bednorz and Mueller discovered high temperature superconductors in 1986 and were awarded the Nobel Prize in Physics in 1987. In 1989, it was reported that the metal palladium, when densely loaded with hydrogen, particularly the mass two isotope deuterium, produced so much heat that known chemistry could not explain the observed energy. This immediately led to speculation that nuclear processes had to be responsible for the anomalous heat production, a potentially even more amazing discovery. These discoveries share a common property: they occur in complex solids operating under conditions not normally found in nature. They are so-called many-body systems, whose complexities are legendary. An unusually readable and scientifically superb account of superconductivity is available from Herbert Frohlich "The Theory of the Superconductive State", Reports on Progress in Physics, Volume XXIV(1961).

The discoverers of what they called "cold fusion", Martin Fleischman and Stanley Pons, set off a scientific firestorm by speculating that chemical systems can control nuclear processes. Their 26 April 1989 testimony before the Committee on Science, Space, and Technology of the US House of Representatives included a speculation that, if deuterium was indeed the fuel in their experiments, then they had measured a process that produced at least eight times as much energy as was required to operate the "reactor", which would burn that fuel. This claim was incredible to those who had labored intensely for 40 years trying to build machines that would burn deuterium by simulating the conditions found in the sun. But, they had yet to demonstrate they could produce enough energy to sustain operation of their "hot fusion" reactors. The experiments had even not reached "break-even." Even more incredible to those versed in nuclear physics was the absence of harmful levels of ionizing radiation or neutrons. Furthermore, the Fleischmann-Pons experiment seemed simple and cheap, which it was in terms of equipment, but not in terms of the physical processes involved.

In retrospect, the Fleischmann-Pons Effect (FPE) experiments, which showed that the chemically impossible amounts of energy generated by deuterated palladium, were anything but simple. They involved the complexities found in materials science, nuclear physics, electrochemistry, and other disciplines, plus the analytical challenge of trace element detection and quantification. The majority judgment made in the Department of Energy's November 1989 Report of its Cold Fusion Panel, part of the Energy Research Advisory Board, asserted that the large quantity of measured heat was an experimental artifact. The Panel's report is a marvel of bureaucratic civility and correctness. It delivered with finesse a door-closing end to further serious consideration by the general science community. The tension between the panel members and the co-chairman, Prof. John Huizenga, is captured in the line from the Executive Summary: "The Panel also concludes that some observations attributed to cold fusion are not yet invalidated." But, true to the threat that a new mouth to feed would be added to the nuclear and particle physics research table, the following was produced: "The Panel recommends against the establishment of special programs or research centers to develop cold fusion. However, there remain unresolved issues, which may have interesting implications. The Panel is, therefore, sympathetic toward modest support for carefully focused and cooperative experiments within the present funding system." To our knowledge, all LENR proposals from non-DOE laboratories have been rejected for funding by the DOE. Interestingly, Prof Huizenga promoted his provocatively entitled assessment of the matter in his 1993 book Cold Fusion: The Scientific Fiasco of the Century. Professor Huizenga had been Chairman of the National Academy of Science Committee on Nuclear and Radio Chemistry that was in place in the late 1980s. His unyielding vigor in lobbying colleagues on the committee for the narrow interests of his field of specialty was noteworthy. He attended ICCF-4 in 1993, but found no compelling evidence in what was presented there. As late as 1999, in an interview during press conference on the tenth anniversary of the FPE, Huizenga was holding to his position: "It's as dead as ever."

Most of the essential elements of the DOE Panel critique of the FPE heat discovery have been extensively examined and addressed in the literature, particularly as to the presence of an effect. However, there does not exist at this time a "simple" experiment with a clear theoretical explanation, which comes with the two-body scattering models that have been the bread and butter of the nuclear physics world. There are strong experimental indications that some nuclear processes are modulated by the environments inside solids. Notably, the enhancement of fusion cross-sections in metals and compounds containing deuterium has been measured in diverse experiments.

Despite the very limited amount of work done on the FPE compared to the complexity of the problem, research has been supported by the US Department of Defense, government funding agencies in Japan, Russia, Italy, France, and China, and a number of private investors and closely held corporations. Because some of the investigations do not require large capital investments there is a hardy band of researchers who have independently added important understanding about the FPE. This demonstrates that the industrial science model of post WWII in physics is not the only approach to science. Just as the chemists and biologists have joined forces to dominate late twentieth century science, the FPE offers the opportunity for important results to be obtained by individuals and small groups.

Terminology – What name do you give this discovery?

The field of this conference has been called cold fusion since Fleischmann and Pons speculated that their heat production could only be explained by non-chemical processes, that their fuel was deuterium, and that it wasn't "hot fusion." The term cold fusion was already in use to describe muon-catalyzed fusion, an understood physical mechanism in which fusion of two deuterons occurs at relatively high rates in the presence of muons. In 1989, the term "cold" for the new and mysterious effect, was meant to contrast deuteron fusion at room temperature with known fusion processes in plasmas, which have temperatures of millions of degrees K.

As time passed during the 1990s, processes other than fusion of two deuterons were reported. These transmutation reactions involved and produced isotopes of nuclei with moderate and high atomic weights, and not only two light nuclei undergoing fusion. Because of this, and to emphasize their viewpoints, some researchers in the field sought other names for the effect announced by Fleischmann and Pons. A tabular summary with the various names applied to "cold fusion" follows, plus our comments on the strengths and weaknesses of the various names.

Table 1. Names given to the study of “cold fusion” since 1989

Terminology	Comments
Cold Fusion	Original and recognized name, but incomplete
Low Energy Nuclear Reactions	Low is a relative term and unclear
Lattice Enabled Nuclear Reactions	Clear and specific, but very new and little known
Lattice Assisted Nuclear Reactions	Also accurate, but little used
Chemically Assisted Nuclear Reactions	Many chemists like this
Cold Fusion Nuclear Reactions	Little used
Cold Nuclear Transmutations	A Russian favorite
New Hydrogen Energy	A major Japanese program
Metal Deuterium Energy	A current program in Japan
SANER	SAfe Nuclear Energy Release
Fleischmann-Pons Effect	Clear and encompassing

Table 1 shows most of the titles given to the study of “cold fusion” over the 20 years since its announcement. The field is now widely considered to be part of “Condensed Matter Nuclear Science.”

None of these names has gained universal acceptance. In the minds of some workers in the field, they suffer from various shortcomings. For example, "cold" and "low" are relative terms without precise meanings. The variety, and indeed confusion, over terminology is also promoted by the lack of a clear understanding of the basic mechanism (or mechanisms) active in this field. The overall terminology situation was not aided by the foundation of a software company called Cold Fusion, which often shows up in internet searches.

In 2002, a new and broader name was introduced, namely “Condensed Matter Nuclear Science” (CMNS). “Condensed matter” is a term that has been employed by the American Physical Society for a few decades to embrace both solids and liquids. CMNS was meant to focus on the science of nuclear effects in systems involving solids (always) and liquids (often). It is an appropriate description for the current and continuing science of the field, but it will fail to embrace anticipated engineering work based on that science. The International Society for Condensed Matter Nuclear Science was founded in the U.K. in 2003 (www.iscmns.org). It is the primary intellectual scientific society for the field.

At present, given all the problems with the name of the field, many people are simply and clearly referring to the mechanism(s) active in the experiments that followed from the 1989 announcement as the "Fleischmann-Pons Effect" (FPE). That effect is the production of heat and other products in a metallic system under unusual circumstances of very high densities of hydrogen or deuterium. It is interesting to remember that, in the Fleischman-Pons patent application, light water and nickel, as well as other hydrided metals, were included in their claims. Although much of the focus has been on deuterium and palladium, there are credible Italian papers reporting heat being produced from light water and nickel.

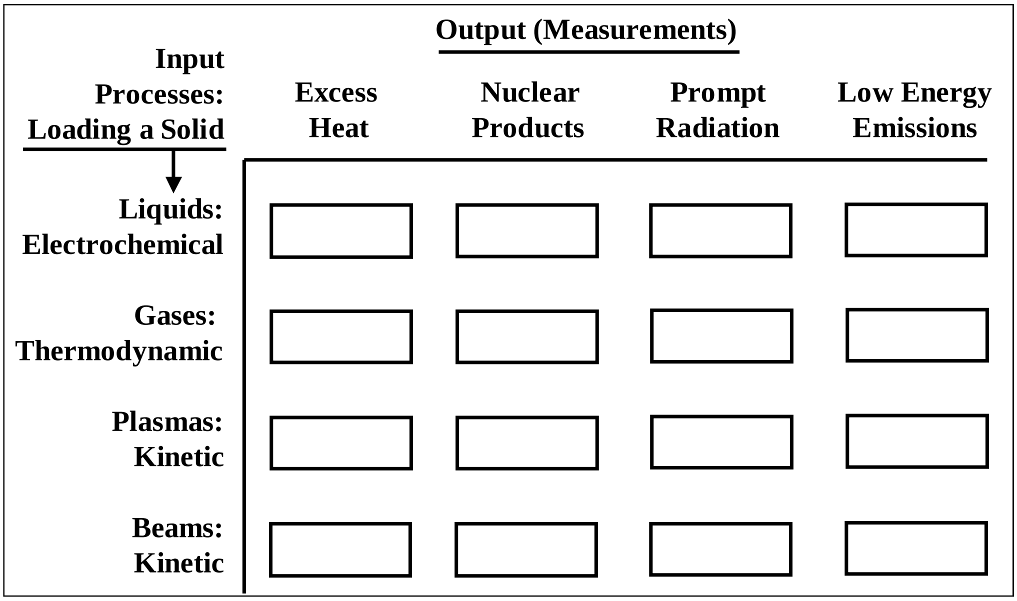

Figure 1. The means of loading protons or deuterons into lattices, and the types of measurements made to prove the existence and determine the properties of LENR.

It is known experimentally that the amount of heat produced per reaction can be over 1000 times the energy released by any known chemical reaction. The power densities (measured in watts per cubic centimeter of the metal) occasionally exceed those in fission nuclear power systems. Associated with this heat in many experiments is the production of helium-4 at levels that account for the heat, if each atom of helium is associated with about 24 million electron volts of energy. Small amounts of tritium, the mass-three isotope of hydrogen, plus other nuclei, energetic particles and photons, and low energy quanta, such as infrared radiation, have been reported for many experiments. Figure 1 shows one way to organize the four means of loading hydrogen isotopes into lattices and the four classes of measurements just mentioned. This arrangement served as the organizing principle for the conference and, hence, for these proceedings.

History of the International Conferences on Cold Fusion

While this sequence of conferences has been the major venue for presentation of results on the FPE effect, its continuation and evolution are subject to much current discussion. The characteristics of past conferences provide a basis for that consideration. The rest of this section presents some statistics on the ICCF and discusses trends over the almost 20-year history of the series. The conferences have generally rotated across three continents, North America, Europe and Asia. The next table is a summary of the dates, locations and the numbers of attendees, papers in the proceedings and authors of those papers. It is based on the proceedings of each conference and other materials, which we have acquired from our attendance at each of the ICCFs.

The number of attendees can be estimated in different ways, all of which have problems. The first method is from the lists published by conference organizers. These commonly contain more names than people who actually attended the conference, so they tend to give high numbers. The second way to estimate the number of attendees is from the official conference photo. The photos usually had some people missing, though they included administrative personnel. Hence, the numbers from the photos are generally low. The last count of attendees is the number given in the proceedings. The reported and published numbers are commonly rounded off. For example, ICCF-2 was said to have >200 attendees. Numbers from the provided lists, from counting faces in conference photos and from the proceedings are given in Table 2. The large discrepancies in the numbers of people attending ICCF-3 and -13 are indicative of the problem of accurately counting attendees. It is likely that the numbers published in the proceedings are most accurate. It must be noted that, in general, not all of the attendees were present for the entire conference.

Table 2. Summary of the dates, locations, attendees, papers and authors for the ICCF conferences

General Information			Attendees				Proceedings	
	Date	**Location**	**List**	**Photo**	**Proceedings**	**Countries**	**Papers**	**Authors**
1	1990	Salt Lake City UT USA	296		>200		35	90
2	1991	Lake Como Italy			>200		57	294
3	1992	Nagoya Japan	324	223	346	18	102	320
4	1993	Lahaina, Maui, HI USA			242	12	65	164
5	1995	Monte Carlo Monaco	207		228	15	76	91
6	1996	Lake Toya Hokaido Japan	175		179	17	110	288
7	1998	Vancouver BC Canada	218		206	21	*89	
8	2000	Lerici La Spezia Italy	145		145	18	68	176
9	2002	Beijing China	113	111	113	17	87	193
10	2003	Cambridge MA USA	135	98	>150		93	170
11	2004	Marseilles France			170	20	74	164
12	2005	Yokohama Japan		58			63	158
13	2007	Sochi Russia	75	52			93	
14	2008	Washington DC	180			15	**97**	

*The ICCF-7 Proceedings have 76 papers presented at the conference, plus 13 additional papers, which were not presented.

The number of papers can be obtained more confidently by simply counting the papers in the proceedings. But not all of the presented papers or posters result in proceeding publications. Similarly, papers that were not presented at the conference are sometimes inserted into proceedings. The author index in the proceedings gives the numbers of people with their names on the published papers. These were counted and tabulated

Given the incompleteness and uncertainty of the number of attendees, it is difficult to be very specific about attendance trends. But the general picture is evident. For the first seven meetings during 1990-1998, attendance was somewhat in excess of 200. ICCF-3 and ICCF-6, both in Japan, were the exceptions in this period. For ICCF 8 through 11, attendance was usually closer to 150. For ICCF-12 and 13, the attendance dropped significantly to well below 100. ICCF-14 had 180 attendees from 15 countries.

The numbers of countries from which attendees came for the ICCFs are shown in the table. Here again, it is not possible to draw any detailed conclusions. However, the overall picture is clear from the numbers given in the proceedings. Generally, 10 to 20 countries were represented at the conferences, and the larger delegations are usually from about six countries. There has been a significant number of attendees from the host country or continent. For example, at ICCF-3, held in Nagoya, 229 of the 346 attendees were from Japan.

The numbers of papers in the proceedings of the ICCF series varies between 35 and 110, with no strong trends over the years. The total for the first 12 conferences is 920 papers, an average of 77 published papers per conference. The total number of papers in the ICCF proceedings probably represents around one-third of the papers on the FPE since 1989. In addition to drawing most of the key scientists in the community, these conferences provide in their proceedings a primary repository of information in the field. There will probably be a need to reprint the proceedings from the earlier ICCFs as the number of scientists in the field increases. However, many of the papers presented at ICCF and published in their proceedings are available on the internet at LENR-CANR.org.

The total number of authors listed for ICCF-1 through ICCF-12, excepting ICCF-7 for which an author index is not available, is 2108. This gives an average of 192 authors for those 11 conferences. The total number over the years necessarily includes double counting of individuals who attended more than one of the ICCFs. It would be laborious to determine accurately how many individual scientists contributed to the papers in the proceedings. But, the number is at least several hundred.

There are significant factors and trends that cannot be gotten from the data in Table 2. The number of reporters present at each conference is not generally recorded. However, from attending these conferences, we know what the general level of press interest has been over the years. Initially, there was great and evident press presence, especially at ICCF-1 and -2. The number of general reporters in attendance declined to few or none throughout the following several conferences, which continued in the most recent conferences. Some researchers welcomed this absence of external scrutiny, which permitted work on the FPE to proceed without distractions from the press. We feel that this field, like any field of science, must be able to communicate its activities and results both to the broader scientific community and to the public generally. When the field is recognized and accepted as a subject for legitimate scientific inquiry, and public funds are made available to researchers in the field, then such communications will become necessary and routine.

Strategies for ICCF-14 and These Proceedings

As noted already, the ICCF series of conferences is on a three-continent rotation. Hence, it was appropriate to hold ICCF-14 in North America. We volunteered to organize ICCF-14 in Washington DC, a few minutes' walk from the national capitol and close to the regional Metro system, with two hopes in mind. One desire was to attract staffers from the nearby offices of Senators and Congressmen. The other was to make it easy for program managers from US government funding agencies to attend, especially those with responsibilities for science, energy and the environment. Such agencies include the US Departments of Energy and

Defense, the National Science Foundation and the Environmental Protection Agency. We also hoped that having the conference in the heart of the US capitol would attract mainstream press coverage. None of these possibilities materialized. However, the CBS TV show 60 Minutes did videotape part of the conference and a report on the field, not the conference, was broadcast in April 2009. The limited number of new local attendees was likely due to the conference being scheduled in August, when many people are on vacation. The ICCFs have uniformly been held in high quality settings that encouraged intense exchanges of ideas. Holding a conference in a capital city is generally expensive and ICCF-14 timing was chosen to reduce the hotel room rates, which were about half of what they are during other times of the year.

Regarding the agenda, conference organizers can be either reactive or proactive in their approach to obtaining papers for presentation. In the reactive mode, they form the agenda from the papers that have been offered in response to a Call for Papers. However, for most conferences, the organizers also invite presentations from important workers in the field that will be of broad interest to the attendees. These invitations are honorific, and they insure that the best work is highlighted.

We felt that some topics in the field needed up-to-date technical reviews at the conference. Hence, we commissioned a few reviews from key workers, in addition to inviting several luminaries in the field to give papers. The commissioned reviews were on:

1. Calorimeter design and performance for measurement of excess power and energy in the FPE experiments.
2. The experimental evidence of excess heat, the Fleischmann-Pons Effect.
3. Experiments using gas loading to produce excess heat.
4. Scattering of deuterons on deuterons within a metallic environment to assess the “screening” at energies below the coulomb barrier.

It is hoped that the commissioned papers will form the basis of later papers in a mainstream review journal, such as the Reviews of Modern Physics. These papers are identified in the introductions to the sections in which they are found in these proceedings.

The architecture of the agenda was chosen for a few purposes. One such goal was to provide during the first two days of the conference a broad overview of the field. The very important work on heat and materials was scheduled on the opening day. This was done to insure that people who could attend only one or two days of the conference would be able to get a sense of the breadth and quality of what has been done and found in the field. This strategy proved to be very successful.

Several people in the field, who have made major contributions to its development, are well past retirement age. It was felt that the chances to publicly honor such pioneers would likely be few. Hence, we scheduled two sessions on the second day to honor Professor Yoshiaki Arata from Osaka University in Japan and Dr. Stanislaw Szpak from the SPAWAR Systems Center in San Diego. The session for Professor Arata began with an overview of his work on cold fusion, and ended with a presentation by Professor Arata on his most recent and very provocative results. That session was organized by Dr. Talbot Chubb, who gave the overview.

The session for Dr. Szpak, who could not attend, consisted of an overview of the work he and his colleagues have done and published since the inception of the field. It was organized by Frank Gordon and presented by him and a few colleagues of Dr. Szpak's. We hope that future ICCFs will also include sessions recognizing key pioneers in the field.

The second day also included sessions on three very important topics: gas loading, particle measurements, and challenges facing the field. In the evening, the annual public session of the International Society for Condensed Matter Nuclear Science (ISCMNS) was held. It was organized and chaired by William Collis, the organizer and Chief Executive of the Society.

There are four classes of measurements done on FPE experiments: heat, nuclear ash, energetic particles, and low-energy phenomena, as already noted. The measurements of nuclear reaction products have tended to fall into two main classes, namely the detection of light products, such as tritium and helium, and the measurement of elements of moderate or heavy mass. The second type of research goes under the banner of transmutations, and is of widespread interest and major importance in the field. Hence, the opening session on the third day was on transmutations. However, there was too little time in that session to cover all the work in the sub-field. Hence, Professor George Miley from the University of Illinois organized a workshop on transmutations on Friday afternoon immediately after the conference. Approximately 50 scientists attended, which is a measure of the interest in transmutations.

Most of the third day was designed to serve workers in the field, both technically and for recreation. There was a session during which leading workers from several countries presented histories of work on the FPE in their countries during the almost two decades since the inception of the field. Presentations were made on work in China, France, India, Italy, Japan and Russia. This session was a major step forward in a separate project to produce and publish country histories for activities and results in the field. Some already exist in either English or the language of the country. Translations to English are in progress, with the goal of publishing a matched set of books, one for each country, in the near future.

The afternoon of the third day was devoted to the traditional conference outing. Most of the attendees participated in a visit to the Udvar-Hazy Center of the Smithsonian Air and Space Museum about an hour's drive from the conference hotel. The conference banquet was held after the tour on the third day. In addition to the meal and musical entertainment, the evening included the presentation of the Preparata Medal to Dr. Irving Dardik. The medal was prepared by William Collis on behalf of the ISCMNS. Dr. Michael McKubre gave introductory remarks, prior of the presentation to Dr. Dardik and his remarks. Several members of the Dardik family and other friends attended the dinner and award ceremony.

The fourth day of the conference included two sessions on modeling and theories that covered a very broad range of ideas. Theoretical ideas had the most papers at the conference. There were also full sessions on ion beam experimental results, on optical experiments and another partial session on materials. That Thursday included the last of three poster sessions, the other two being late on Monday and Tuesday of the conference.

The conference concluded with a half day of presentations. Several significant experimental papers, which did not fit well in the earlier sessions, were given in the first session. That was followed by the concluding session, which included Dr. Thomas Passell's conference summary, followed by two panel discussions. The first dialogue was on Experimental Design and the second was on Realizing the Promise.

During this conference, the accumulated evidence was reviewed to show that the FPE is not an experimental artifact. The feedback from attendees indicated that ICCF-14 was a successful scientific conference. The 97 papers scheduled for oral or poster presentation included some very important new results. The information given at the conference and published in these proceedings adds significantly to the large and increasingly compelling evidence for the ability to trigger nuclear reactions, which give millions of electron volts of energy, with chemical energies on the scale of electron volts. This new and exciting scientific field is sufficient in itself. However, the possibility of clean and safe distributed nuclear power sources based on the FPE makes understanding, controlling and optimizing low energy nuclear reactions even more interesting and urgent.

This ICCF was the Fourteenth to present research results that have been developed and published by hundreds of investigators world-wide. The DOE has conducted within its national laboratories important experiments on the production of tritium in non-conventional FPE inspired configurations. The US Patent Office (PTO), as a matter of policy since the 1989 DOE Report, has rejected all devices that assume the existence of the FPE, citing the popular press accounts that say it does not exist. Clearly, the DOE and the PTO are now only occasional followers, and not leaders, of the limited understanding of the FPE. (Note added in proof: the World Intellectual Property Organization published a "cold fusion" patent on 15 October 2009.)

These proceedings depart from past documentation of the ICCF. As with the earlier volumes, the papers are binned into sections by topic. However, we seek to make the proceedings useful to a wider audience than the attendees and people already familiar with the field. Hence, we provide an introduction to each of the sections. Those introductions have two parts. The first is a technical overview of the subject of the sections. For example, the introduction to the section on calorimeters defines the various types of calorimeters discussed in the following detailed papers given at the conference. The second part of the introductory material for each section briefly cites or summarizes each of the papers in the section. It is hoped that both aspects of the section introductions will make these proceedings more useful, especially to students, who are needed to advance the field in the coming years.

Summary of the Field

The experiments in many countries over 20 years have given the field a very strong database. Part of that key data was presented at this conference. The experience to date has revealed both problems and progress. We begin with a "high level" summary of the current technical and other problems. Then, issues that have been resolved are summarized.

Unresolved Technical Issues

- Most fundamentally, the mechanisms at the heart of the production of heat by LENR are not understood, despite about two-dozen theories.

- Unknown material properties apparently play a key role in producing the FPE.
- The characteristics of the nanometer-scale locations at which LENR occur are unknown.
- Reproducibility of LENR is still below 100% in almost all experiments.
- While significant factors are known for triggering the FPE, the controllability of experiments to date is unsatisfactory.
- The net power levels from experiments to date are only on the order of 10 watts, well below what is needed for most applications or profitable commercialization.
- Continuous power production from the past experiments rarely exceeds one month.

Unresolved Support Issues

- Adequate government funding is not available for research on the FPE using modern tools, such as synchrotron radiation and atomic-force microscopes.
- Major journals and science magazines still refuse to publish papers from the field because it is still haunted by an early and poor reputation.
- The US Patent and Trademark Office generally has not approved patents on LENR based devices and processes, which deters investments by venture capitalists.

The last three problems are all due to the scientific community, which alone can legitimize the study of LENR, continuing to ignore the field for a variety of reasons. Negative statements by some prominent ex-scientists exacerbate the inattention problem. Because the study of LENR is still only a science and not yet a technology, products based on nuclear reactions at ordinary temperatures may take one or two decades to appear. However, predictions of this sort are notoriously dependent upon the cumulative man-hours devoted to studying these complex systems and the "luck" that investigators have in these largely Edisonian searches.

Resolved Issues

The above problems notwithstanding, major progress has been made on the characteristics of the FPE in the past two decades. Based on many measurements by credentialed scientists with good equipment, proper calibrations, adequate controls, and good signal-to-noise ratios, we now know that:

- It is possible to initiate nuclear reactions, each of which gives energies of about one million electron volts, by using chemical energies on the order of one electron volt.
- High temperatures are not needed to produce LENR, greatly simplifying the experimental study of the phenomenon and its potential applications.
- There are four approaches to FPE experiments, namely the use of liquids, gases, plasmas and beams to load hydrogen isotopes into certain solids, notably Palladium.
- Four types of measurements, heat that cannot be explained by chemistry, nuclear reaction (transmutation) products, low intensities of energetic particles and some low-energy phenomena, all point to the occurrence of nuclear reactions.
- Power gains in excess of ten have been observed in a few experiments
- Power densities exceeding those within nuclear fission fuel rods by 100 times have been measured.
- Values of generated energy (in electron volts per atom of the metal catalyst) in excess of 20,000 have been observed in FPE experiments.

- **The experiments do not emit dangerous radiation during their operation.**
- **No significant radioactive waste has been observed after FPE experiments.**
- **LENR do not produce greenhouse gases.**

Concluding Thoughts

As a result of the empirical knowledge now in hand, it is not unreasonable to imagine safe and green sources of nuclear power for homes, free of carbon emissions, which also will relieve stress on the power grid, because they might be small and distributed. LENR could be the basis for portable nuclear power sources, maybe even batteries. The production of clean drinking water by desalination or by purification of polluted river waters is one of the many, and perhaps the most attractive potential applications of LENR. The world health implications of clean water would be momentous. Those of us who work on the Fleischmann-Pons Effect find it an exciting and challenging field of research with remarkable practical potential. As a scientific effect, it is already historic. It remains to be seen if it will turn out to be a “game changing” practical source of energy. The field is indeed EXCITING NEW SCIENCE and it offers POTENTIAL CLEAN ENERGY.