MINUTES OF THE

November 5-6, 2002

BASIC ENERGY SCIENCES ADVISORY COMMITTEE

MEETING

Gaithersburg Marriott Washingtonian Center
Gaithersburg, MD

Geraldine Richmond
Chairperson

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UNIVERSITY OF OREGON

BASIC ENERGY SCIENCES ADVISORY COMMITTEE

Meeting Minutes
November 5-6, 2002
Gaithersburg Marriott Washingtonian Center
Gaithersburg, MD

I hereby certify that these minutes constitute a reasonably comprehensive and accurate record of the meeting of the Basic Energy Sciences Advisory Committee held on November 5-6, 2002.

Geraldine Richmond, Chairperson

April 14, 2003
Date

Minutes are available on the BESAC website at:
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Minutes for the
Basic Energy Sciences Advisory Committee Meeting
November 5-6, 2002
Washingtonian Marriott Center, Gaithersburg, Maryland

BESAC members present:

Nora Berrah
Philip Bucksbaum
Mostafa El-Sayed (Tuesday only)
George Flynn
Laura Greene (Tuesday only)
John Hemminger
Eric Isaacs
Anthony Johnson
Walter Kohn (Wednesday only)
Gabrielle Long (Tuesday only)
Anne Mayes
William McCurdy, Jr.
Daniel Morse
Martin Moskovits
Cherry Murray
Ward Plummer
John Richards
Geraldine Richmond, Chair
Richard Smalley
Joachim Stohr
Samuel Stupp
Stanley Williams
Mary Wirth

BESAC members absent:

Collin Broholm
Patricia Dove
D. Wayne Goodman
Bradley Moore, Vice Chair
Kathleen Taylor
Rudolf Tromp

Tuesday, November 5, 2002

Chairwoman **Geraldine Richmond** called the meeting to order at 8:35 a.m. She welcomed the new members and had all the members introduce themselves. She called upon **Raymond Orbach** to give a sense of where the Office of Science (SC) is going. He said that the Committee has had a profound influence on the direction of the Office. The leadership BES has taken on energy production is terribly important and greatly appreciated. He called attention to the occasional papers that have been issued by SC. They reflect priorities of the Office. High-end computation is a critical need. We have peak speeds of 10 to 12 Tflop/s, but the efficiency of the machines is limiting. We need simulations to complement theory and experiment. He had met with the vice presidents in charge of research at General Motors and General Electric. They pointed out the need for virtual prototypes (e.g., to increase the efficiency of gas-fired generators). SC had held 11 workshops during the summer to identify areas in need of such support. Some areas identified: catalysis, combustion, and astrophysical processes. Teams of computer scientists, mathematicians, and scientists are needed for this research. They need specialized computer tools for ultrascale computing, not the one-size-fits-all type of computer chips, architecture, and algorithms currently used. Clusters of computing opportunities may occur among related fields of science. Such computational resources will be analogous to the DOE light sources. This is believed to be a major path forward for scientific discovery. SC's advisory committees are the prime mechanism for deciding how to proceed in this endeavor.

The status of U.S. education is calamitous. More than half of the natural science students are foreign nationals. In a recent year, 125,000 social-science degrees were granted by U.S. colleges

and universities and only 19,000 natural-science degrees. The Department will reintroduce programs to bring high-school and college teachers and students into the DOE laboratories and have them work with laboratory personnel. This program was very successful in the nineties and produced a statistically verifiable improvement in science education. Language has now been put into proposed funding legislation to allow and fund such programs.

About half of SC's research funding now goes to universities and about half to national-laboratory personnel. Those resources are supporting team-driven, high-risk, high-payoff science. SC's research is complementary to the science done by other U.S. agencies. Long-term support for science is very important. He thanked the Committee for its efforts and intensity to ensure continuation of this support.

Stupp asked if the science education effort will be coordinated with the National Science Foundation (NSF). Orbach responded that SC is closely coupled with NSF . The Department of Education is also active in science education, and DOE is working closely with that department. DOE is a small player. When the program was zeroed out, the laboratories took it over and funded it out of laboratory resources. DOE wants to fund people full time in the laboratories to lead this effort.

El-Sayed asked if he had thought about establishing fellowships for graduate students. Orbach answered that that that is NSF's role. They have funding exactly for that. What DOE is supplying is the laboratory setting for the work of those fellows.

Mayes asked what magnitude of funding is being proposed. Orbach answered that DOE's support will be much smaller than NSF's. It will start at one national laboratory and expand to all 10 national laboratories.

Richards asked why there is a decrease in the budget for biological research. Orbach suggested that he watch what the Secretary does on November 25. The current budget is the President's budget. It does not have the congressional markups yet. It is not known what the FY03 budget will look like ultimately.

Morse pointed out that the success rate of applying to NSF for funds is 12%. This is too low a reward for students to pursue science. In opting for education in the social sciences and humanities, they are voting with their feet. Orbach observed that this low rate of reward is not a new phenomenon and agreed that it has a negative effect not only on students but also on scientists submitting proposals.

Williams called attention to the fact that the direction of present-day computer architecture is dominated by the large consumer market and that the market has been condensing to a few suppliers. He suggested that SC should put together a council of computer architects and get them excited about the needs and possibilities of high-end computing. Orbach responded that SC has done just that and that the vendors have responded very positively. The commodity chip emerged from the consumer market. We are trying to convince computer vendors that there is a market for the chips, architectures, and algorithms of ultrascale computing. Scaling up will have a huge impact on the geosciences, energy generation and transmission, and many other applications. This is a 10-year project; DOE is trying to speed up that progress. The government may need to build, own, and operate the core machine, but the vendors are the critical element. Williams warned that in using such a top-down approach, one does not engage the important people in the trenches. It is important to reach into the community of architects. Orbach agreed and said that SC was doing both. McCurdy agreed with Williams. For sustained change, the culture of architectural design has to be changed. In the nineties, there were dozens of

architecture groups in academia. Now there are just a few; we have a long way to go. Computer scientists must be brought back into the process.

Richmond noted that Rita Caldwell at NSF is trying to increase the value of individual graduate-student fellowships. It will be a struggle to fund this. DOE may not be able to be an active player because of the limited funds. She asked his perspective on how SC can keep up with this trend. Orbach responded that SC has had flat funding for the past 10 years, which resulted in a 20% decrease in buying power. It will fund the graduate programs as much as it can, focusing on needy areas, including accelerator science and computer science.

McCurdy asked how DOE will "grab onto" the education issue. Orbach replied, through the national laboratories; DOE will use the national laboratories to support the NSF and Department of Education efforts.

Smalley pointed out that the energy problem is world-wide and that a workplace-preparation mission needs to be crafted for DOE. Orbach agreed and said that be believed that it *is* part of DOE's mission.

Richmond turned the floor over to **Patricia Dehmer** to give an update on BES. Dehmer started with the FY03 budget

The Senate has marked up the President's budget request for BES with an additional $25 million, including an increase in the Experimental Program to Stimulate Competitive Research (EPSCoR) and $4,500,000 in additional funding to complete preliminary engineering and design and move to construction at the Center for Integrated Nanotechnology at Los Alamos National Laboratory (LANL). The House Appropriations Committee had complimentary words on the Department's Nanoscience Initiative and included $1,000,000 to begin preliminary engineering and design in fiscal year 2003 for the nanoscience research center at Brookhaven. Additional funds were included for computational sciences in materials and chemistry.

Within the FY03 budget are increases for the Materials Sciences and Engineering Division and the Chemical Sciences, Geosciences, and Biosciences Division and increases for operations of major scientific user facilities (averaging about 5%). The final appropriation may be known in December.

The past seven years have spanned two presidents, three and a half congresses, four Secretaries of Energy, five directors of the Office of Science (including Jim Decker twice), and seven budgets appropriated (almost). A lot has been done in BES during that period. It has transitioned from the Advanced Neutron Source (ANS) to the Spallation Neutron Source (SNS), one-half of SNS has been constructed (7-1/2 years total construction), the National Nanotechnology Initiative (NNI) was launched, the nanoscience centers were conceived and are under way, the fourth-generation light sources have been considered, and the Linac Coherent Light Source (LCLS) is under way.

DOE and SC are now beginning a new strategic-planning process. The Department is aiming at a 25-year time horizon. Its plan will be organized around 15 to 20 goals, with several relevant to SC, including scientific research, science facilities, and a number of crosscutting management goals. The draft is nearing completion and will be published for public comment within a month. The Office of Science's plan is to adopt a 5 to 10-year time horizon and be organized around compelling, exciting science, with additional focus on facilities and science management. The plan will be completed by March of 2003. For this exercise, Orbach has asked that each office articulate the four or five most important broad science challenges for the next 5 to 10 years. These themes should capture two-thirds or more of the office's envisioned program investments.

SC is publishing a series of occasional papers, one of which is the product of BES: "The Beauty of Nanoscale Science." Other topics that were considered included "Controlling Chemistry: Making the Right Stuff," "Theory, Modeling, and Computational Simulation," "Seeing Atoms," "The New Imperative for Fundamental Research in Energy," "Solar-Energy Conversion," and "How Plants Work: A Systems Approach to Understanding the Wonders of Nature's Nanomachines."

BESAC advice has been central to describing the challenges BES has faced in

- Neutron source upgrades and the specifications for the SNS;
- Novel, coherent light sources;
- Complex systems;
- Biomolecular materials;
- Opportunities for catalysis science in the 21st Century;
- Theory and modeling in nanoscience;
- Basic research needs to assure a secure energy future; and
- Fourth-generation light sources.

For the strategic-planning process, BES needs to describe four or five themes. The broad challenges, as seen by the BES staff, are:

- Realizing the nanoscale revolution by tailoring materials one atom at a time for desired properties and functions and by controlling chemical reactivity with designer catalysts
- Complex systems: Understanding collective, cooperative, and adaptive phenomena and emergent behavior
- Harnessing the power of advanced computing for condensed matter and materials physics, chemistry, and biosciences (Orbach's highest priority in SC)
- Fundamental research for national and energy security
- Seeing atoms: Providing national user facilities for probing materials at the atomic scale

In this list, complex systems is separate and distinct from nanoscience and nanotechnology. The basic theme of the Shank report on complex systems is that interactions among individual components can lead to coherent behavior that can be described only at higher levels than those of the individual units. This interaction can produce remarkably complex and yet organized behavior, including magnetism and superconductivity, complex pattern formation and growth, and living systems.

In probing materials at the atomic scale, X-ray, neutron, and electron scattering techniques have opened the world of the ultrasmall. The next challenge is to open the world of the ultrafast at this same spatial resolution by support of the SNS, LCLS, and TEAM (the Transmission Electron Achromatic Microscope).

Orbach needs a plan for the future to support the FY04 budget and to gain direction for the FY05 budget. She asked the Committee to think about the five themes presented and, at the next morning's session, to talk about how to proceed with them. This has to be done now because the FY04 budget will have been submitted to Congress by the next BESAC meeting.

In addition to discussing the proposed themes for the new SC strategic plan, BESAC needs to continue (1) conducting workshops, special panels, and reviews and (2) providing advice on components of the BES plan.

She showed an organization chart of the Office, noting that six new, permanent program managers and one IPA [an Intergovernmental Personnel Act detailee] had been hired and that two more were on the way. Also, two new support staff had been hired, and Walter Stevens had

accepted the position of Director of the Chemical Sciences, Geosciences, and Biosciences Division.

The nanoscience center user workshops have been well attended by more than 2000 attendees and have addressed the research themes of these facilities, each of which has a different research mission.

She noted that the revised catalysis workshop report was being distributed at this meeting and asked the Committee to be prepared to comment on it at the following morning's session.

Greene asked if the Committee could we modify the five themes. Dehmer answered that it could. The Office needs to select three to five themes that represent its upcoming research agenda.

Williams asked what the appropriate pressures that can be brought to bear on the funding process are, noting that Hewlett-Packard's research budget has doubled every five years. Dehmer responded that there are rules that advisory-committee members have to follow and that she, as a federal employee, may not lobby. She noted that there is resistance to doubling any budget over any period. The only way the argument will be won is to point out compelling ways to advance science, technology, and the standard of living through specific initiatives. The entire Office of Science will be using these words over the next year.

Isaacs asked what Congress expects of DOE and SC. Dehmer responded that BES has multiple missions: to do science research in disciplines that underpin energy production and use and to provide scientific facilities for the nation. It provides the linkage between societal needs and basic research.

Mayes asked about the schedule of the SNS. Dehmer said that it will be completed in mid 2006.

McCurdy asked what impact previous strategic plans have had and how have they evolved. Dehmer replied that she was only present for one other strategic plan under Martha Krebs, an effort that was driven by the undersecretary. It was divorced from the budget. This administration has stressed the need to tie strategic planning to the budgeting process. All of DOE is looking at strategic planning. All five themes cited are linked to budget increases. This Committee and SC need to identify where to put the investment.

Isaacs asked how homeland security ties into this plan. Stevens answered that he would talk about that subject in the afternoon session.

Murray asked if, with a flat budget, the Committee suggests new activities in the planning process, whether that means other things have to be cut. Dehmer responded, that is right.

Stupp asked whether the Committee's reaction to the five themes was being requested. Richmond responded positively. The draft of the catalysis report was distributed for review by the Committee. In the discussion of the following day, the planning process should have priority, followed by the catalysis report, followed by upcoming BESAC activities. She declared a break at 10:28 a.m.

The meeting was called back into session at 11:02 a.m. with the introduction of **Linda Horton** to report on the BESAC workshop on Basic Research Needs to Assure a Secure Energy Future, which was held October 21-25, 2002, in Gaithersburg. The workshop was chaired by John Stringer, and he will be at the February BESAC meeting to present the workshop report.

The purpose of the workshop was to identify the fundamental scientific challenges that BES must consider in addressing the DOE missions in energy efficiency, renewable energy resources, improved use of fossil fuels, safe and publicly acceptable nuclear energy, future energy sources, and reduced environmental impacts of energy production and use. The workshop was broken

down into eight topical areas: fossil energy; distributed generation (including fuel cells and hydrogen); nuclear energy; industrial, residential, and commercial energy; transportation; renewable energy; fusion energy; and crosscutting research (which looked for omissions; this panel included the chairs from the teams covering all the other topical areas).

A three-phase process was adopted to answer the charge. In Phase I, Stringer selected chairs for the topical groups; the chairs selected the members of the topical groups; the topical groups prepared recommendations for discussion and development at the workshop; and the topical groups reviewed and revised draft factual documentation of the workshop. In Phase II (the actual workshop), additional members were added to the topical groups to form topical teams; the teams developed recommendations for proposed research directions; the teams prepared supporting statements for their proposed research directions; and the proposed research directions from all the topical groups were prioritized.

Phase III is currently under way. In it, information is being expanded with a follow-up meeting on biological opportunities in energy research and the preparation of the report, including appendices that will incorporate the summary of the workshop activities, the proposed research directions for each topic, and the factual documentation. This report will be available at the February BESAC meeting.

The workshop leadership included academia, the national laboratories, industry, and other DOE offices on each team. Some teams included additional invited speakers during their portion of the program.

She reviewed the schedule of the workshop, which included presentations from DOE's SC, Office of Energy Efficiency and Renewable Energy (EE), Office of Fossil Energy (FE), and Office of Nuclear Energy, Science, and Technology (NE); breakout sessions; closing topical-area summaries; an assessment of crosscutting research; and the initiation of Phase III (summarizing proposed research directions, identifying overlapping topics, discussing logistics for the coordination and assembly of the results, identifying the needs for the expansion of the collected information, and defining the schedule and template for documentation).

The proposed research directions from each of the groups will be described in detail in the workshop report. The following major themes were identified by the topical teams:

- Materials research to transcend energy barriers, including
  - Nanomaterials
  - Novel materials for energy
  - Degradation of materials
  - Radiation effects
  - Solid state lighting
  - Sensors
- Biology, including
  - Photovoltaics
  - Photosynthesis
  - Biomass
- Research for the hydrogen economy, including
  - Hydrogen storage and synthesis
- Energy storage
- Novel membrane assemblies, including
  - Fuel cells
- Heterogeneous catalysis, including

- Theoretical computational aspects
- Advanced experimental techniques

Energy conversion, including
- CO_2-free technology
- Solar
- Energy Systems Modeling
- Fuel cells

Utilization/efficiency
- Solid state lighting
- Sensors
- Multilayer thin films
- Deposition processes

Nuclear fuel cycles and actinide chemistry

Bucksbaum noted that greenhouse gases do not seem to have been mentioned at the workshop. Horton responded that there was a lot of discussion of that topic and concern about it is pervasive in the topics reported (e.g., the hydrogen economy and CO_2-free technology).

Mayes pointed out that the Industrial Research panel ran out of time and did not cover industrial-energy research needs well. Horton commented that a lot of work has been done in this sector, which represents 30% of the national energy use. Mayes said that the timetable does not have much time for the Committee to review the report. Dehmer stated that BES needs the report long enough before the February BESAC meeting to respond to it.

Richards said that fast reactors were discussed at length in the nuclear team meeting but the topic was not explained to those at the workshop who did not work in that area. Horton said that several people from the GEN-IV Forum (which is exploring the possibilities for the fourth generation of nuclear power plants) were members of the nuclear-energy breakout group, and that topic received significant discussion there.

Morse asked if anything was discussed on alternative chemical pathways or storage. Horton answered that some chemical processes were discussed and something may be captured in the topical summaries that did not make it into her summary.

Stupp noted that some biological topics emerged at the workshop and asked what that discussion was about. Horton said that in renewables, revolutionary advances need to be made to make biomass use effective. Biomimetics came up in a number of topical discussions, but the workshop probably did not have the right expertise to address the topic adequately; the Subcommittee is seeking more input. [A follow-up session is planned for January to address this topic.]

Smalley noted that the big challenge for photovoltaics is to reduce costs by a factor of 10 to 100. Plants can only convert radiant energy to chemical energy with an efficiency of 1%. A key question is, how efficient *could* the process of converting radiant energy to electrical energy be made? That question emerged as a fascinating research area and is "in the mix" for the report.

Bucksbaum stated that another omission in the report is inertial fusion energy. Horton responded that that topic may have been excluded because it does not fall under BES but rather under the Office of Fusion Energy Science (FES).

McCurdy noted that the report seems to be becoming a list. It should make a case about what has changed and needs to change. What is missing from the catalog of research needs is important but it is not *all* of the problem. Horton commented that that concept was discussed a

lot at the workshop and will be reflected in the report. There is not a single solution to the energy problem but many regional energy needs and solutions.

Berrah asked if there would be a section on implementation. Horton said, no; that will be left to BES. Smalley said that the purpose of this report is to show what the magnitude of the problem is, and it should open the eyes of decision makers and of students going into the field. Richmond said that scientists have a responsibility to take the message to the public and to policymakers. Smalley added that what is being discussed here is a huge problem, and the answer has to come from the physical sciences, which have had flat funding for years. These problems (e.g., fuel cells) will require decades of research. The technology to solve the problem is not in hand or even in pilot plants now. This problem should resonate with high school and junior high school students.

Berrah commented that this report should be presented to a number of programs that various agencies support. Horton suggested that a starting point would be to prepare a set of view graphs that such programs could use.

Greene stated that the final report should present a catalog and instructions on how to use the elements together. Horton said that the reader should see both: the details from the working groups and the summary synthesis.

Flynn observed that several studies on this topic were conducted in the seventies and asked if anyone had gone back to see how things had changed since then. Horton said that an earlier BES report had been looked at along with many other historic documents. This *is* an old problem, but now there are new tools and techniques available that might be use to resolve the problem.

Richmond thanked Horton and Stringer for their work and declared a break for lunch at 12:05 p.m. She called the meeting back into session at 1:35 p.m. and asked **Terry Michalske** to present an update on the nanoscience research centers. He introduced **Murray Gibson** to describe the Center for Nanoscale Materials (CNM) at Argonne. That center has funding from the state of Illinois for construction of the building, which will be attached to the Advanced Photon Source. BES will fund the equipment for the Center. The start of construction is anticipated during summer 2003. They are setting up advisory committees, identifying facilities and instruments for a "jumpstart user program," coordinating the user interface with the Advanced Photon Source (APS) and the Intense Pulsed Neutron Source (IPNS), and planning an FY03 Nanoscience Workshop and CNM Summer School.

Mark Alper described the Molecular Foundry at Lawrence Berkeley National Laboratory (LBNL). It is based on six user facilities, one each in inorganic nanostructures; nanofabrication; organic, polymer/biopolymer synthesis; biological nanostructures; imaging and manipulation; and theory. The Foundry building will be near the National Center for Electron Microscopy (NCEM) and Materials Sciences laboratories; design will be completed during the first quarter of FY03, with construction starting in the fourth quarter of FY03. The design includes ultralow vibration and electromagnetic radiation facilities. Occupancy is to start in 2006. They are hiring lead scientists and issuing calls for proposals soon.

Doon Gibbs described the status of the Brookhaven National Laboratory (BNL) Center for Functional Nanomaterials. It will be near the electromicroscopy facility. It will focus on electron microscopy, theory and computation, materials synthesis, nanopatterning proximal probes, and ultrafast optical probes. The conceptual design is in process. It will have a Lehman review in February 2003. Engineering will start in March 2003, and construction will start in FY05. The science thrust areas are strongly correlated oxides, magnetic nanoassemblies, nanocatalytic materials, charge injection and transport, nanostructured organic films. A proposal study panel

(PSP) and a science advisory committee have been established. Eight workshops have been held to introduce potential users to the laboratory's capabilities. Preliminary hires have been targeted.

Linda Horton described the status of the Oak Ridge National Laboratory (ORNL) Center for Nanophase Materials Sciences, which is collocated with the SNS. It will focus on material research needs in neutron science; synthesis and integration of hard and soft materials; and theory, modeling, and simulation (TMS). They also have a jump-start users program with a focus on nanofabrication, synthetic and bio-inspired macromolecular materials, catalysis, nanotubes and related materials, nanoscale magnetism and collective behavior, oxide materials integration, nanoscale imaging and manipulation, and TMS. The design is 90% completed; CD-2 [critical decision 2] has been approved; the next Lehman review is December 02 followed by CD-3 in February of 03; construction will start in 2003. The second planning workshop had 315 registrants from 88 institutions; it identified the scientific community's greatest challenges and opportunities.

Terry Michalske described the Center for Integrated Nanotechnologies. They have appointed an outreach coordinator and a lead scientist. Its CD-01 was approved in June 2002, its Title 1 design is in progress, and the LANL gateway performance specifications have been initiated. A Lehman review scheduled for the fourth quarter of FY03; start of construction is expected in January 04. The Center will focus on nanoelectronics, nanophotonics, nano/bio/micro interfaces, complex functional nanomaterials, nanomechanics, and theory and simulation. They have formed a management team, a joint-laboratory memorandum of understanding (MOU) has been signed, a governance board has been established, and a scientific advisory committee is being set up. They are setting up cooperative agreements with several materials user facilities and major National Nuclear Security Administration (NNSA) facilities, and are drawing up user agreements.

The Nanoscience Research Centers (NSRCs) rollout is designed to get the word out about the availability of these centers. The centers' staffs have set up a common format for websites, common materials for communicating about the NSRC Program, are approaching a set of professional societies, are preparing a viewgraph briefing package, and will hold a workshop for potential users in February. **James Roberto** invited all of BESAC to that workshop, to be held at the Renaissance Hotel, Washington, D.C., February 26-28. 2003. It will be a forum for communication among agencies, policymakers, and the scientific community and to

1. Learn about national research priorities in nanoscience,
2. Learn about research opportunities, and
3. Participate in the first national users meeting.

Program highlights include keynote presentations, scientific and industry sessions, perspectives from key politicians, agency presentations on the NNI and on research opportunities and resources, a banquet speech on future priorities for federal research, student poster sessions from the NSRCs, and a users meeting with presentations by Pat Dehmer and center directors. More information can be found at www.ornl.gov/doe_nsrc_workshop/. This workshop is scheduled to start the day after the next BESAC meeting.

Greene commented that this workshop is important. There needs to be cross-fertilization among the centers. Future presentations should stress how the work at the different centers has different focuses and is complementary.

Williams noted that Hewlett-Packard (HP) has had a nanoscience research center for two years. They did not do any advertising and have been swamped with customers and users from within the company to say nothing about from the outside. When you build centers like these, the

users will come. DOE needs to plan how to handle the crush of users. Smalley asked him what facilities were the most popular. Williams answered, nanolithography.

Richmond congratulated **Walter Stevens** on his new position as Director of the Chemical Sciences, Geosciences, and Biosciences Division of BES and asked him to summarize the news from the division. He reviewed the division's organization chart, pointing out that two new staff members had been added and one lost; four positions were open. Increases (in millions of dollars) from FY02 in the requested budget are

Photochemistry and Radiation Research	3.1
Catalysis and Chemical Transformation	6.6
Separations and Analyses	1.4
Heavy Element Chemistry	1

A solicitation in Nanoscale Science, Engineering, and Technology was issued in FY02. On the university side, 532 were preapplications received; 194 were encouraged; and 341 formal applications were submitted. Nineteen grants totaling $5.3 million were funded from the Chemical Sciences, Geosciences and Biosciences Division; twenty-seven grants totaling $4.8 million were funded from the Materials Sciences and Engineering Division for a total of $10.1 million awarded to universities. On the national-laboratory side, submissions were restricted to four proposals per laboratory; 37 proposals were received, and 12 awards were funded, with most applicants receiving partial funding. A total of $7.9 million was awarded to the national laboratories.

The BESAC Panel on Theory and Modeling in Nanoscience met in San Francisco in May. Its purpose was to identify the challenges and opportunities for theory, modeling and simulation in nanoscience and nanotechnology and to investigate the role of applied mathematics and computer science in meeting those challenges. Its formal report was submitted to and accepted by BESAC in July. A solicitation for research proposals is expected to be issued in FY03 with $3.0 million from the Office of Advanced Scientific Computing Research (ASCR), $1.5 million from Materials Science and Engineering, and $1.5 million from Chemical Sciences, Geosciences, and Biosciences. The solicitation will seek collaborative projects between applied mathematicians and computational scientists to (1) advance our ability to predict the structure and properties of nanoscale materials and (2) understand the relationships between properties and composition, structure, and size.

Another BESAC workshop was held in Gaithersburg in May on Catalysis Science in the 21st Century. A revised draft of the workshop report was distributed to the Committee for its review. Funding of $6.5 million is available from Chemical Sciences, Geosciences, and Biosciences in FY03 for multidisciplinary projects aimed at understanding and controlling catalysis at the molecular level and for studies of catalysts' synthesis, structure, kinetics, dynamics, and structure/function relationships. A solicitation for proposals is expected.

Another Chemical Sciences, Geosciences, and Biosciences workshop was held on water and radiation chemistry in Richland, Washington, on September 25-28, 2002. Its goal was to identify the important questions in electron-driven processes and radical chemistry in aqueous systems and to identify the most promising approaches to solving these problems. It had 50 participants.

He gave an update on the BES Workshop on Basic Research Needs to Counter Terrorism, the objective of which was to identify critical science issues and opportunities in research areas supported by BES that will be important to our nation's ability to detect, prevent, protect against, and respond to future terrorist threats. The outcome was a report that summarizes the presentations and discussions and includes recommendations for future basic research

investment needs. It is available at http://www.sc.doe.gov/production/bes/counterterrorism.html. The workshop focused on the scientific issues underlying the detection, containment, sampling, analysis, decontamination, and destruction of

- Chemical threats: Including conventional explosives and toxic chemicals such as choking agents, blood agents, blister agents, nerve agents, and byproducts of their manufacture.
- Biological threats: Including bacteria, rickettsiae, viruses, fungi, and toxins. Gram for gram much more deadly than chemical agents. Can be bioengineered.
- Radiological and nuclear threats: Including nuclear explosives and radioactive materials and by-products of their manufacture.

A major question is the proposed Department of Homeland Security (DHS), which has been proposed by the President. This reorganization will be the most significant transformation of the U.S. government in more than a half-century. The creation of this cabinet-level agency is an important step in the President's national strategy for homeland security. Some parts of DOE will be transferred to DHS for nuclear antismuggling, chemical and biological nonproliferation, and pathogen sequencing. DHS will also have access to DOE national laboratories under work for others or joint sponsorship. The proposed research structure includes (1) intramural research (mostly classified) hosted at DOE national laboratories, (2) extramural research (mostly unclassified) hosted mostly at universities, (3) a Security Advanced Research Projects Agency (SARPA) for out-of-the-box technology development, and (4) the development of standards [with the National Institute of Standards and Technology (NIST)] for homeland-security field measurements. The agencies affected by the creation of DHS are *very* numerous, and dozens of Congressional committees are tied into the consideration of the DHS. In the meantime, the SC national laboratories have named points of contact for homeland security. Those laboratories have also been asked to get in touch with state and local first responders to see if the national laboratories can be helpful to them.

A Nobel Prize in physics was won by Ray Davis, whose work was supported by the Atomic Energy Commission (AEC) Chemistry Office.

Upcoming workshops include one on plant systems biology for the production of chemicals or fuels. A planning meeting will be held at the University of California at Riverside in January 2003, and the workshop will be held in the Washington area in the spring of 2003. Another planned workshop will look at the evaluation and future of the electrochemistry programs of BES.

Near-term activities include (1) a new hire in computational chemistry and modeling to manage BES participation in the SciDAC program, elements of Chemical Physics, and elements of Photochemistry and Radiation Research and (2) an expansion of BES's catalysis research with a $6.5 million solicitation in catalysis science.

In the long term, plant systems biology will influence imaging and modeling tremendously. Similarly, computational science and simulation as a tool for scientific discovery will be an equal partner with theory and experiment. A lot of discoveries will come out of simulation. BES will have a $6.0 million solicitation in theory and modeling in nanoscale science, which will have a broad impact on all Division programs.

Finally, Chemical Sciences, Geosciences, and Biosciences is trying to increase the number of fellowships available.

Morse noted that genome sequences are important in plant-systems biology. A further advantage lies in the ability to leverage the combination of biophysical studies of plant energy-transduction systems with the powerful new advances in plant genomics. Stevens replied that

BES has been supporting several sequencing projects. The Office of Biological and Environmental Research (OBER) plays a major role, and BES needs to coordinate with them.

El-Sayed noted that grants for instrument development would be very useful, and Stevens agreed.

Bucksbaum pointed out that the NSF is also trying to find out how basic science can contribute to counterterrorism and asked how BES is working with them. Stevens replied that the Office is closely coordinated with them and others, and they attend and contribute to our workshops.

Flynn noted that, as El-Sayed had pointed out, the physical sciences can make a tremendous contribution to sensors and detectors. But it produces a cynicism in the research community when you have 200 proposals and can only fund 19 or 20. Stevens replied that DOE can ask for preproposals to help narrow down the field and to eliminate unnecessary effort, but it cannot stop anyone from submitting a proposal. Greene commented that the message there seems to be: never submit a preproposal. Wirth asked if it was a DOE rule that anyone can submit a proposal. Millman said that SC operates under 10CFR, Part 605, which is a subset of Part 600. That portion of the Code says that DOE can use preproposals, but it *cannot* limit people from submitting proposals on the basis of such preproposals.

Smalley asked if there were data on BES research funding to indicate what the erosion of that funding has been. Dehmer replied that how much money is available for research is known, the official deflators known, and the annual increases in funding are known. Applying those deflators to the funding levels produces a flat line for funding. If more realistic deflator rates are used, a 15 to 20% decrease per year is obtained for the past 10 to 15 years. Stevens added that BES has seen the number of months a postdoc works on a project erode.

Mayes noted that a large number of proposers were not encouraged and asked what percentage of those submitted proposals. Stevens said that he did not have that number, but could get it. Bucksbaum pointed out that the number of people that were encouraged was *still* much larger than the number of grants available and that DOE *does* have control over the number encouraged. Stevens countered that the number of proposals received was *still* almost double the number encouraged. Also, the preproposals are screened only on programmatic relevance, not scientific merit. Morse offered that the scientific community would be better served by requiring preproposal acceptance for proposal submission. One has to do some pruning. Stevens replied that the nanoscience call was the first major solicitation run out of BES for many years and noted that a more narrowly focused request will also thin down the number of proposals.

Plummer asked why any reasonable high school student would go into a career in science just to get into this mess. Morse added that such cynicism will filter down to high-school students very quickly. The rationality of the selection process needs to be increased. As the number of proposals grows, the randomness of selection increases.

A break was declared at 3:18 p.m. The meeting was called back into session at 3:58 p.m., and Richmond called upon **John Galayda** to present an update on the Linac Coherent Light Source (LCLS). The LCLS will be the world's first hard X-ray laser, producing unprecedented brightness with an unprecedented time resolution. Its 0.8- to 8-keV self-amplified, spontaneous-emission (SASE) free electron laser (FEL) will have a peak power in the SASE bandwidth of 8 GW, a peak brightness of 1033 photons/(mm^2 mr^2 0.1%BW), a pulse duration of less than 230 femtoseconds, and a pulse repetition rate of 120 Hz. It was first proposed in 1992; its CD-0 was approved in 2001; its conceptual-design report (CDR) is now on the Web; engineering design is

slated to begin this year; construction is expected to be started in 2006; the laser is expected to be fired up in 2007; project completion is expected in 2008. He reviewed the operation of the machine. The total estimated cost range is $200 million to $240 million, and the total project cost range is $245 million to $295 million.

The project engineering design begins with the preparation for long-lead procurements in 2005 of the undulator, gun laser, and injector linac systems. In spring 2003, the plans for long-lead procurements must be reviewed; at that point, the CD-2A go-ahead will be required. In spring 2004, the preliminary design of the LCLS is to be completed, and the CD-2 requirements completed for the entire project.

Critical Decision 1 was approved 16 October 2002, meaning that the conceptual design is judged sound, the preliminary hazard analysis is accepted, the acquisition execution plan is accepted, and the preliminary project execution plan is accepted. However, DOE is now operating under a continuing resolution. Because this project is a new startup, it gets no funds under a continuing resolution.

A workshop on Experimental Opportunities with LCLS was held October 8-9, 2002. It had 30 attendees, including the "first-Experiments" co-authors. The LCLS Scientific Advisory Committee (SAC) discussed the proposal/review sequence. The primary purpose of the workshop was to identify R&D needs in terms of timing and related diagnostics, detectors, and damage studies that are prerequisites to proposals. Also discussed at the workshop was basing the LCLS science program based on the Stanford Synchrotron Radiation Laboratory (SSRL) model, which means that

- Experiment proposals will be developed by leading research teams with SSRL involvement;
- Proposals will be reviewed by the LCLS SAC;
- Research teams will secure outside funding with SSRL participation and sponsorship, as appropriate;
- SSRL will manage construction (which provides cost and schedule control, rationalized design, and a basis for establishing the maintenance and support infrastructure); and
- SSRL will partner with the research teams to commission the endstations.

Operations will switch to a "general user" mode with beam-time allocation based on SAC recommendations.

The LCLS team will prepare proposal guidelines and call for letters of intent with a late spring 2003 target for submission. These letters will be submitted to LCLS SAC review, whose evaluation will lead to a request for preproposal R&D funds if necessary. Proposals will be reviewed by SAC, and DOE will review/approve proposals in the 2005 time frame.

Stanford Linear Accelerator Center (SLAC) is currently collaborating with the Deutsches Elektronen-Synchrotron's TeV-Energy Superconducting Linear Accelerator (DESY/TESLA) on free-electron lasers with SLAC delivering a bunch-length measurement system to the TESLA Test Facility (TTF). An expanded collaboration during the next few years was agreed to on November 1, 2002. Under that agreement, a Sub-Picosecond Photon Source (SPPS) at SLAC will be produce 9-keV X-rays with the SLAC linac and the Final Focus Test Beam, DESY personnel will participate in the commissioning, and DESY will join in SPPS experiments from 2003 to 2006. In 2003 and 2004, SLAC personnel will participate in the commissioning of the TTF; and in 2005 to 2006, they will participate in experiments to control temporal coherence. In 2011, TESLA expects SLAC participation in the commissioning of TESLA's XFEL [X-ray FEL]. The machines are very similar; they have similar photocathode guns.

The two institutions have also been cooperating in trying to understand coherent synchrotron radiation, in which radiation at the back of an electron bunch catches up to the front of the bunch. This process has been quite an irritant, but the researchers expect to be able to deal with it.

Short-bunch diagnostic tests are planned for TESLA and SLAC under the memorandum of agreement; a cavity and klystron will be sent to TESLA for testing. The 50-fs light pulse is still accompanied by a "pedestal" 3-ps electron bunch. This pedestal needs to be eliminated to make use of the light pulse. Several techniques are being used to produce a narrower pulse.

A new technical design report will be released soon that will scale down the TESLA XFEL Laboratory to a 20-GeV linac, three FEL undulator sources, and two spontaneous undulator sources.

The SPPS does not have a photon gun but uses a pulse from the SLAC storage ring with a 12-m chicane compressor inserted one-third of the way down the beam to test synchronization, short-pulse diagnostics for X-ray beams, and control of timing and pulse length.

The undulator R&D is progressing well. Prototype construction is complete. Field quality specifications have been met. The investigation of thermal stability is ongoing.

In conclusion, the LCLS is poised to start project engineering design. The preliminary design of the undulator and injector is the next procurement hurdle. The LCLS collaboration is well matched to the LCLS challenges. And experiment program planning is under way, based on the successful SSRL model.

Johnson asked if there was any chance that the electron beam will distort the crystal structure. Galayda replied that that was a concern but that the beam will not be sent *through* the crystal but *near* the crystal. Johnson asked why there was the $50 million spread in the construction cost. Galayda replied that the planning procedures require such a range be included until CD-2 for planning purposes, to allow for delays in the construction schedule and to allow some flexibility in how the facility is outfitted.

Williams asked if the instruments are to be designed in response to the needs expressed by the user community. Galayda answered, yes. Proposals will proceed separately from testing of optics, etc.

Bucksbaum asked if the technique used by TESLA was a single shot. Galayda said that he did not believe so. Bucksbaum noted that he had mentioned the Sub-Picosecond Pulse Source (SPPS) and asked how that project affects the LCLS. Galayda said that the SPPS is attracting researchers and will provide the first chance to assess timing and synchronization techniques for the LCLS; but with regard to coherent synchrotron radiation effects, the SPPS is unrelated. Its first experiment will be to measure the timing and structure of the X-ray pulse that comes out of the SPPS; the electron bunches and the X-ray pulse will be the same length in the SPPS but not in the LCLS. One must have an independent means of measuring the X-ray pulse.

Plummer asked if any money was forthcoming from Stanford or the State of California. Galayda said that Stanford is considering hiring personnel; California is not providing any assistance.

Isaacs asked how close we are to having an electron gun that works. Galayda replied, very close. Results from the Gun Test Facility and from Japan are right at the performance borderline.

Richmond called for discussion of the BES planning themes from those who cannot be at the next day's meeting. There being none, she opened the floor to public comment. There being none, she adjourned the meeting for the day at 4:38 p.m.

Wednesday, November 6, 2002

Richmond called the meeting to order at 8:35 a.m. and asked Dehmer to remind the Committee of her needs for input. Dehmer noted that SC's strategic planning for the next several years ensues later in the week, and each office within SC must discuss the three to five major themes that it will pursue during the following 5 to 10 years. She had listed the five proposed themes for BES in her presentation the previous day and would like to hear the Committee's reactions to them.

Bucksbaum pointed out that the themes offered were national challenges. The theme of seeing atoms does not cover the ground intended; it leaves out the motion of atoms, for example. Dehmer said that the associated text will make that distinction clear. Bucksbaum suggested that "Seeing atoms move" might be more descriptive, then. Kohn noted that others have seen atoms move and have shown pictures of that motion. He pointed to the work of Nobel Prize winner Ahmed Zewail, where one can see what happens at every moment and which has obvious implications. Stohr expressed several concerns about what should be selected to *cover the next 10 years*. During that period, science will achieve the requisite resolution to see chemical bonds and to determine anisotropies. Dynamics can be looked at from a chemical viewpoint: scientists will be able to watch chemical reactions occur. From a physics point of view, science will be able to look at ordering that depends on spin and charge. All this needs to be captured. Morse asked how the benefits of all this could be explained to Congress. Stohr said that it is obvious. [Laughter.] It ties into all the other issues of DOE stewardship.

Bucksbaum commented that the difficulty is that the subtitle *is* the challenge: to provide the facilities, instruments, personnel, etc. is the mission and the challenge.

Williams suggested some sub-bullets, such as "threats and protection" and "clean and abundant energy."

Stupp urged editing some of the items in regard to molecules. It is important to talk about making materials one molecule at a time. Seeing atoms is not a challenge, but putting them together is. Imaging those changes in structure is also a challenge.

Isaacs stated that these challenges must be stated in such a way as to excite individual researchers to join the pursuit of those challenges, not just to explain these topics to Congress. McCurdy said that he could not see such an excitement and vision in the way the themes were expressed. He pointed to the third theme, saying that it misses the point that what is important is not just numbers but understanding. He pointed out that the realms of possibility have changed radically with rapid advances in the past 10 to 15 years and suggested expanding this item to include more than just hardware.

Johnson said that, given its long-term horizon, the plan needs to consider the trends in education mentioned by Orbach on the previous day. Women and minorities need to be tapped to produce the scientific workforce needed by our technological society. Orbach mentioned that half of the nation's doctoral-degree recipients in science and engineering are foreign nationals. What was not mentioned was the fact that the upcoming changes in the demographics of the United States would presage even fewer U.S. doctorates in science and engineering as the number of white males interested in these fields continues to decline. These exciting fields offer a wonderful opportunity to attract women and underrepresented minorities into science and engineering.

Flynn commented on the absence of anything about replication as a necessary follow-up to self-assembly. Also, the themes should say how technology can solve the energy crisis [e.g., by

pointing out the lower power consumption of flat displays vs CRTs (cathode-ray tubes)]. With regard to security, mentioning the detection of biological, chemical, and nuclear agents is crucial.

Smalley was uncomfortable with the atom-by-atom model of manufacturing; there are too many molecules in a mole; one is not going to make any material that way. There is not enough emphasis on *making stuff* in this list of themes.

Plummer added that the list of themes needs to include the simulation, design, and fabrication of new materials. This country has not done a good job in making stuff.

Mayes suggested boosting energy security to the top of the list; it is the major DOE mission. Opportunities for reduction of usage of energy should be added to this list.

Wirth advocated (1) adding another theme of "new technology and measurement at the nanoscale" and (2) clarifying the concept of complex systems. Dehmer stated that complex systems covers everything from chemical reactions to superconductivity to large organisms. Richards asked if it covered genomes, too. Stevens said that that type of research is done by other agencies. Richards stated that he also would like to see complex systems defined and the items reordered.

Hemminger indicated that, if education was added and if implementing the nanoscience revolution and seeing atoms were combined, the list would be improved. Berrah said that she also would like to see education/workforce introduced into the list of themes.

Murray commented that she was hearing several goals (reduce energy by 20%) and several themes (what we have been talking about). The overarching goal for DOE is fundamental research for national and energy security. In that mission there are three grand challenges for BES:

1. Clean, affordable the terawatt sources of energy,
2. Science and technology to reduce U.S. energy consumption by 20%, and
3. Single-molecule detection for threat detection and prevention.

The cross-cutting themes used to meet these challenges are world-class facilities, beautiful science, high-performance computing, and education and training for the workforce for the 21st century. The first three of these are necessary for BES to realize the nanoscale revolution and for understanding complex systems.

Stupp said that one goal is single-molecule detection. Complex systems is a broad challenge. Much of the science in complex systems is biological. Biological systems should be mentioned more explicitly here, and being able to use and mimic biological systems should be cited.

Smalley suggested that "emergent and adaptive behavior" is more descriptive than "complex systems." Bucksbaum said that he did not understand the term "emergent behavior." Smalley explained that a hurricane is an emergent behavior. Richards added that things evolve without outside intervention.

Williams stated that, despite the Committee's collective word smithing, Dehmer had done a good job of selecting these issues and showed great vision in doing so.

Hemminger noted that environmental-impact issues are not reflected in these themes. Dehmer said that another office in DOE is responsible for environmental research but that, certainly, all energy research has to take the environment into consideration. Hemminger suggested adding the word "environmental" somewhere.

Murray commented that some of these items should be more specific. What the Committee has been talking about is the science that underlies the grand challenges.

Johnson asked if Congress is aware of the amount of fundamental science that is done in DOE. Dehmer replied that Congress is very aware of the role of SC in advancing fundamental research.

Richmond declared a break at 9:29 a.m. The meeting was reconvened at 9:56 a.m. to consider the report of the workshop on catalysis for the 21st Century. William Millman summarized the effort that led to this report, and Dehmer noted that this is a DOE report that should articulate the scientific challenges in catalysis for BES. Richmond pointed out that, unfortunately, the perception that was communicated to the Subcommittee was that the only way to get money from DOE was to establish a research center. As a result, the workshop was set up with the purpose of addressing the question of whether or not catalysis research centers should be instituted, and the resulting report overlooked a number of other purposes and topics of the workshop.

Millman solicited comments about the current draft of the report from the Committee. The general comments were that the report needed

- A concise executive summary,
- A clear concept of its audience and purpose,
- The definition of major terms,
- A definitive statement of the benefits and opportunities offered by improved catalysts,
- A statement of the economic importance of catalysis and of the improvement of catalysts,
- A demonstrated connection between (1) catalysis and (2) energy production and use,
- A set of specific recommendations, and
- A call for DOE to address these issues.

The Committee members suggested that the report should express an excitement about what can be done with catalysts; examples of the benefits of using catalysts; the influence that advanced catalysts could have on emission reductions; the identity of materials for catalysis and their design; the names of people (e.g., Ziegler, Norskov, Scheckler, and Ertl) who are world leaders in catalysis research and what they have developed and are currently working on; and an outline of what work needs to be performed in catalysis in the foreseeable future. Many good people were at the workshop and they brought with them excellent ideas and perspectives. The report should reflect their input, and it should focus on the great opportunities that exist in catalysis. It should not recommend what a request for proposals (RFP) for catalysis research should say.

Stevens reminded the Committee that a motion had been passed at the previous BESAC meeting calling for an RFP to be issued for catalysis research. As a result, $6.5 million is being held in the FY03 budget for that research, and an RFP needs to be issued before the next BESAC meeting. Richmond asked if the substance of that motion was still the will of the Committee. A unanimous show of hands indicated consensus that the Committee stood by that motion.

Richmond suggested that (1) a working group be assembled under the oversight of Stevens to rewrite the report, (2) the group include some experts from the workshop as well as some BESAC members and perhaps some others, (3) the new version of the report incorporate the suggestions offered by the Committee members at this meeting, (4) the rewritten report be put up on the Web in January, and (5) an e-mail vote of the Committee be held to approve or reject the rewritten report. Richmond asked for consensus on this approach to finalizing the workshop report. A unanimous show of hands affirmed consensus. Richards appointed Plummer, Richards,

and Hemminger to the group that is to rewrite the catalysis-workshop report. Richmond asked the group to caucus to select a path forward.

The catalysis-report working group reported that they had agreed to put together a small group that included Peter Stair, Jens Norskov, Bruce Gates, and John Bercau from the workshop attendees plus Mostafa El-Sayed and Wayne Goodman from BESAC to put together a new report to be available for review by mid-January. Mayes asked if the recommendations in the new report would be the same as those previously approved by BESAC. Stevens answered that supplementary recommendations may be added; the report has to form a roadmap for BES to proceed in catalysis.

Kohn asked if everything would be rewritten. Stevens replied that that was his understanding. All of the people added to the group had been at the workshop. Plummer added that the goal was to produce a report that was similar to the *Theory and Modeling in Nanoscience* report, giving the history, the opportunities, the benefits, and the path forward.

Richmond once again asked the Committee if this was the way it wanted to proceed with the catalysis report. A unanimous show of hands affirmed that the Committee was in agreement with this course of action.

The meeting was adjourned at 11:54 a.m.

Attached as Appendix A is a written statement received October 23, 2002, via electronic mail. It is included as a public written statement only. It does not reflect the scope, objectives, or opinions of the Basic Energy Sciences Advisory Committee. This written record is included only to ensure compliance with Federal Advisory Committee Act (FACA) regulations and the language of the Federal Register Notice.

Submitted Nov. 23, 2002
Frederick M. O'Hara, Jr.
Recording Secretary

Revised Jan. 15, 2003
Linda L. Horton

Appendix A

October 23, 2002

TO: Sharon Long, Department of Energy
Basic Energy Sciences Advisory Committee
FROM: William Simmons
President
Energy Metals Corporation (EmC)
SUBJECT: Written Statement for the Record to the BESAC Nov. 7-8 Meeting
REFERENCE: Recommendations for Science Research

Dear BESAC Members and Committee,

Thank you for the opportunity to offer a novel idea to the Committee. And that is to pursue research opportunities that actually offer a real time solution for the number one dilemma facing

our society. That being nuclear waste and a practical disposition of spent fuel and material left over from the production of nuclear weapons. Once this is accomplished then possibly the return to the trivial research subjects you have supported in the past and are now pursuing could then be taken up again.

Getting right to the point of the matter, we at EmC feel that the DoE should support cost-effective means to make nuclear waste benign so that the radioactivity of the waste is reduced to a level whereby it is unable to further undergo radioactive decay.

Rather than simply encapsulating nuclear waste and storing it away for 10,000 years, the DoE should support processes and options that will make the waste benign.

The advantages over current practices and mindsets should be evident but may we offer just some of the benefits for your consideration.

Background

In or around 1957 the National Academy of Sciences proclaimed that the only suitable means to deal with nuclear waste was to bury it. This was the beginning of the myth that burial was the only viable treatment available and to this day that myth is continually perpetuated.

Under the Waste Policy Act of 1982 Congress initiated that mindset by passing a deep geological disposal act into law.

The Amendment of 1987 dictated that only Yucca Mountain would be the site.

During this time, studies were made for 'alternative treatments' with no logical solution to show for it. Some were not safe while others were too costly allowing the myth to live on.

Today society will have to live with burial whether it is at the site in trenches or at Yucca Mountain because the material is still lethal and still dangerous since it is still very much radioactive.

At the present, whole industries have developed into billion dollar enterprises based on 1957 technology and the product of that industry is still as lethal as the day it was produced. And yet research dollars are haphazzardly being spent with no practical solutions for the good of this society to show for it.

Premise

To be truly effective and accepted by society for the good of the environment and future generations to come, a suitable waste treatment needs to address its inherent dangers. And that is the radioactivity. To do these three things must occur:

FIRST – A treatment process must make the waste product benign in a safe manner that is complete and permanent.

SECOND – A treatment process must treat the waste on an industrial mass production scale of magnitude.

THIRD – A treatment process has to be cost effective and on par or below the cost of vitrification.

IF A TREATMENT PROCESS REGIME CANNOT PROVIDE THESE BASIC REQUIREMENTS AND AN END PRODUCT THAT IS BENIGN THEN IT IS NOW OBSOLETE AS A TOTAL REGIME.

New Technology – New Order

By allowing the waste to be made benign at the site where it's currently stored and produced will give society control over the radioactive nightmare that to date is not being accomplished by the Department. In fact Waste Management, a nineties term, will be changed to Waste Control for that is exactly what will happen. Control of nuclear waste instead of the management of it will become the norm.

EmC's technology is vital for Homeland Security. HLW is currently being stored at Hanford and produced at 131 sites in 39 states and 161million people live near these facilities. Moving the waste to a geologic repository for further storage only concentrates and compounds the issue since the issue remains the fact that the waste is still lethal.

EmC's technology will secure the future of an economical, clean, reliable power source that allows society to embrace nuclear power and all the benefits that it brings because the waste can be made benign. However, society does not deserve the legacy of nuclear waste that failed past and present treatment programs will leave it to deal with in the future.

Transportation of nuclear waste is no longer safe because of the fact that it is still lethal, still dangerous, and still radioactive. Ever since that dreadful day in Oklahoma City that will forever show to some whacked Timothy McVie wanna be type what a rented truck packed with common fertilizer could do to a building, or a truck or a rail car carrying a nuclear waste canister as it passed by. Please make no mistake they too would be vaporized. It's a different world we now live in than the one of 1957, 1982, 1987 and 1994. Controlling the waste at site is the answer.

Accelerated transmutation (ATW) for instance will never be cost effective and some even question that it even works; therefore it is not practical nor does it justify further funding.

Nevertheless its intent was correct, only its means was not. Today, as we speak the nuclear waste dilemma has already been solved by private industry. Vitirfication is outdated. Our solution is both practical and cheaper than burial with an added bonus that no other current treatment can offer. Cheaper, better, faster equals safer, prudent and permanent. Nothing else can compete.

Therefore reducing the lethalness, the danger -the radioactivity of the waste above any other course of treatment is by far the most pragmatic to pursue over and above any other course of action at this time. Especially when our process can be demonstrated for immediate implementation that is technically and scientifically superior to vitirification and burial because the waste is no longer radioactive. Such a breakthrough needs to be supported by the DoE rather than stymied simply because its maze of institutions, labs and horendous spending was not able to deliver it.

Why bury nuclear waste hot when it can be made benign cheaper?

Don't the people deserve state of the art technology?

Society will be waiting for your answer.

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