

**Comments of Christopher Paine, Nuclear Program Director, Natural Resources Defense Council, regarding National Academy of Sciences Review Committee PIN: DEPS-BPA-10-03, "Prospects for Inertial Confinement Fusion Energy Systems," and its provisional membership**

**Comments on the Charge to the Committee**

The Committee's scope statement says "it will also prepare an interim report giving DOE guidance to assist the department in FY 2012 IFE program planning." This part of the charge undermines the credibility of the entire review. The task presumes that the committee will have concluded within the next six months that a FY 2012 IFE Program is a meritorious idea, and that the Committee will have recommendations intended to shape and influence the FY 2012 DOE fusion energy research budget request. This grossly prejudices the outcome of the full review, acts as an unwelcome "rush to judgment" mechanism on the interpersonal dynamics within the committee, and strongly communicates to outside observers that the committee's review is really just another Washington kabuki play and put-up job designed to transition the existing NNSA-funded ICF effort, currently grounded in nuclear weapons concerns, to a more marketable and hopeful IFE "frame." If the committee cares at all about its credibility and making a genuine contribution to public understanding of the issues, it will drop this interim report.

The scope statement then goes on to say, "A Panel on Fusion Target Physics with access to classified information as well as controlled-restricted unclassified information will serve as a technical resource to the committee and will describe, in a report containing only publicly accessible information, the R&D challenges to providing suitable targets on the basis of parameters established and provided by the Committee. The Panel will also assess the current performance of various fusion target technologies."

Unfortunately, no information is given on the membership or specific charge to this "panel," even though it is an intrinsic, indeed crucial component, of the larger review. The use of the word "Panel" in this context suggests that it will be a panel of the larger committee review, but we were informed today that this is not the case, and that the panel will be comprised of a completely different cast of characters, as yet undisclosed. This mode of proceeding does not represent good faith compliance with the statutory undertakings the Academy accepted in 1997 when it was exempted from complying with FACA . Since they will be functioning together, with the panel informing the deliberations of the larger committee, the memberships and charges of both should be posted and available for evaluation *together*. This panel represents an autonomous and apparently unaccountable source of potential bias in the committee's report, the more so since all of its deliberations will apparently be in secret. The membership of the full Committee should not be finalized until the membership of the "Fusion Target Physics Panel" has been posted, and the public has had the standard opportunity to comment.

**The charge to the full IFE Committee**

The charge states the Committee should prepare a report that will:

"Assess the prospects for generating power using inertial confinement fusion; Identify scientific and engineering challenges, cost targets, and R&D objectives associated with developing an IFE demonstration plant; and advise the U.S. Department of Energy on its development of an R&D roadmap aimed at creating a conceptual design for an inertial fusion energy demonstration plant."

It would seem hardly necessary to point out that in the absence of any demonstration that controlled ICF in the laboratory is technically feasible, any NAS analysis of the "cost targets and R&D objectives associated with developing an IFE demonstration plant" would seem to be wildly premature, and amounts to an open invitation to orchestrated feather-bedding by the DOE fusion research complex.

Since the current wording of the charge to the committee seems to assume favorable answers will be forthcoming soon to the essential underlying questions of scientific and technical feasibility, the report will most likely go on to spin out unsupported and inherently speculative cost and performance projections, while postulating spurious “targets” for the next round of investments in costly fusion energy “demonstration” facilities. This has been going on in both ICF and MFE for 50 years, and it really should stop.

How can one even begin to meaningfully assess the technical extent and cost of the practical “challenges” of constructing an *IFE power plant*, when the basic feasibility of lab-scale fusion has yet to be demonstrated??? Everyone is behaving as though NIF has already succeeded, when in fact the NIF project, seven years late and billions over budget, is stumbling, badly. We don’t even know whether NIF is operating within the right scaled energy/wavelength/target regime needed for ignition. The Halite-Centurion results from the 1980’s underground tests, the only proof of principle we have for ICF, neither confirm nor conclusively deny the combination of energy-scaling and wavelength adopted for NIF, but what empirical confirmation they do offer does not support the design choices made in the NIF.

So why the unseemly rush to declare victory and move on to the design of an IFE power plant? There have been several such conceptual studies over the decades, and yet another such speculative and forward-leaning assessment merely increases the risk that politicians and the public will be duped once again into believing that fusion energy is close at hand, and thus willing to pony up more billions to sustain the fusion energy community. And I strongly suspect that process of resource extraction is the real point of this exercise -- well isn’t it??

The Academy should reject the DOE sponsor’s easy conflation of the basic science and technology questions surrounding achievement of lab-scale ignition with an analysis of the requirements for a “demonstration or commercial plant”. These are almost totally different discussions, with the first preceding the latter by many years, if not decades. We should not be in the unfortunate position of rolling the dice every 15-20 years on whether some gigantic and ever-more costly fusion machine will somehow fortuitously “succeed” when it rests on a science and technology based that amounts to semi-informed guesswork. Fusion research should be an experimental and computational science program, not a forever premature power plant technology development program.

It is not merely premature but actually harmful from the public policy standpoint to be projecting the notion that we have now reached the stage where we can be rationally quantifying the “challenges” of building a demo power plant. This is what LLNL has been doing lately with its fatuous PR campaign for “LIFE” by 2030. It is completely speculative, self-interested, and therefore utterly misleading and ridiculous.

Science works by exhaustively testing and disproving various hypotheses about how the natural world works until only the repeatedly validated hypotheses are left standing. If DOE is going to have a near term fusion research program at all – which I think is a fair question given the opportunity costs and the global urgency of investing available resources in the *clean energy technologies we already know to be viable* – then it should formulate knowledge roadmaps that highlight, and then systematically proceed to either disprove or validate, critical baseline science and technology thresholds that each of several possible IFE approaches must surmount to achieve practical, repeatable lab-scale fusion. Until DOE has a much firmer grasp of the fundamental science and technology requirements for ignition and control of a fusion reaction in a laboratory setting, and then *from there can actually discern a plausible technical path to cost-effective energy gain*, it is worse than useless to speculate on the “key challenges associated with a demonstration and commercial plant.”

This syndrome actually constitutes a form of scientific misconduct by the fusion science community, designed to squeeze funds from the political system in order to feather the nests of fusion physics labs and practitioners, and the Academy should not be a party to this kind of gamesmanship. One of the most distressing things about the currently dominant approaches to both IFE and MFE is that we already know they are exceedingly unlikely to present cost-effective avenues for generating low-carbon electricity, even if they should “succeed” experimentally at some point in demonstrating an evanescent fusion burn in a “laboratory” the size of three football fields (NIF). LLNL parades this gigantism as though it were a badge of honor, when all it really points to is the non-viability of the NIF technology for cost-effective power generation.

In sum, the Committee’s charge should be focused on asking the hard questions about the true state of the scientific knowledge and technology that supposedly underpins the case for various ICF approaches, most obviously including but not limited to indirect-drive ICF with a solid state laser (aka the NIF Project), and for each proposed approach it should relentlessly bear down on clarifying the fundamental hypotheses and putative capabilities that must be disproven or affirmed, by a combination of peer-reviewed experiments and computer simulations, along the critical path to igniting and controlling a fusion reaction in the laboratory. (LLNL, with the Academy’s blessing, skipped some of these crucial steps in its haste to strike when the political iron was hot, and the country is now paying the price.)

DOE should then be asked to formulate a fiscally modest fusion energy sciences program that focuses on rigorous attempts to “disprove” the enabling assumptions behind the leading alternative IFE approaches, until such time as a truly promising candidate is left standing. One thing is clear – the science and technology that may get us some day to cost-effective fusion power is not anywhere in view and remains to be devised, and thus there is no merit at this stage in elaborating plans for further fusion demo mega-facilities.

### **Comments on the Composition of the Committee Membership**

By law – the *Federal Advisory Committee Act Amendments of 1997* – “the Academy shall make its best efforts to ensure that: (A) no individual appointed to serve [on a committee created after the date of enactment of the Act] has a conflict of interest that is relevant to the functions to be performed, unless such conflict is promptly and publicly disclosed and the Academy determines that the conflict is unavoidable; (B) the committee membership is fairly balanced as determined by the Academy to be appropriate for the functions to be performed, and (C) the final report of the Academy will be the result of the Academy’s independent judgment.”

The composition of the committee as currently constituted fails all three of these tests. Certain members of the committee have “relevant” individual conflicts of interest within the common sense definition of that term. Taken as a whole, the committee membership is not fairly balanced but rather heavily biased toward those who have had career-long associations and in some cases a continuing financial dependence on the DOE fusion energy research program, and therefore cannot reasonably be assessed as being wholly independent of the needs and desires of the study sponsor, the Department of Energy.

(By the way, the project description on the website should clearly state which office(s) and official(s) within DOE have requested the study, and which budget(s) within DOE are funding it. Likewise with the profiles of the committee provisional members, the extent of disclosure is uneven and incomplete. For example, many if not most members of the committee probably have paid consulting relationships that are not disclosed on the web page but should be, along with links to a more complete accounting of their past positions, publications, and committee memberships. This half-hearted job of disclosure suggests an

attitude of merely pro-forma compliance by the Academy with its statutory obligations under the 97 amendments.)

Because of the preceding problems, there is reason to suspect that the views of the sponsor, and/or its contracting organizations that have a stake in the outcome of this review, will exert undue influence upon it, and therefore that the final report will not be “the result of the Academy’s independent judgment.”

I appreciate the genuine difficulty of constituting a committee that has both the requisite scientific and technical knowledge but also remains fairly balanced with respect to the range of expert views regarding the matters before it. This is no easy task.

**Individual conflicts of interest.** First let me stipulate at the outset that I have no reason to believe that any of the provisional members of the committee are anything but honorable and decent persons of high moral character and exceptional accomplishment. The fact that this is true on an individual level, however, does not automatically absolve any member of the committee from having potential or actual conflicts of interest with respect to the functions the Committee has been asked to perform. While the most unsettling type of conflict is usually of a direct or indirect financial nature, a conflict of interest can also take the form of a career or reputational stake in the continuing “success” of the program or programs under review, whether or not such a personal stake has in the past had money associated with it.

Dr. Gerald L. Kulcinski, a provisional co-chair of the Committee, is the Director of the Fusion Technology Institute at the University of Wisconsin-Madison. The institute is a contractor to DOE’s Office of Fusion Energy Sciences, so it is probable that Dr. Kulcinski could have, or could appear to others to have, a direct financial stake in the outcome of the review. For example, Dr. Kulcinski might be expected to oppose, on other than purely substantive grounds, any prospective recommendation by the committee to phase out or radically reduce fusion research in general or IFE research in particular, if such a negative recommendation would severely affect DOE funding for his institute.

Dr. Ronald C. Davidson, a provisional co-chair of the review, directs the Beam Dynamics and Non-neutral Plasma Division of Princeton University’s Plasma Physics Laboratory, a major contractor to the DOE fusion energy program. So he may be expected to have a financial or affiliated institutional interest in continuation of the DOE-ICF/IFE program similar to Dr. Kulcinski’s. Dr. Davidson was also a member of the 1990 and 1996 NRC reviews of the DOE Defense Program’s ICF program that strongly influenced the selection of Livermore’s glass laser technology for scale up into a “National Ignition Facility.” Thus Dr. Davidson could be expected to have a natural vested interest in, and therefore possibly a bias toward, vindicating the rightness of these previous recommendations by continuing to ensure support for the LLNL ICF program, despite its exorbitant costs, lengthy delays, numerous prevarications, and continuing technical difficulties. Dr. Davidson is also a former senior official in DOE’s Office of Fusion Energy.

Dr. Charles Baker, UCSD retired, is currently a consultant to Sandia National Laboratories, a contractor to DOE/NNSA’s National Ignition Campaign (NIC), and he has a 40 year association with DOE national laboratory and industrial contractors to DOE’s magnetic fusion program.

Dr. Roger Bangerter, a leader in the field of heavy ion beam fusion, is the retired former head of Fusion Energy Research at Lawrence Berkeley Laboratory, a DOE contractor, and more recently served as the Chair of the Department of Energy’s Virtual National Laboratory for Heavy Ion Fusion, He formerly worked at LLNL, the largest ICF contractor to the Department of Energy, and at Los Alamos National Laboratory.

Dr. Riccardo Betti, University of Rochester, is director of that university's Fusion Science Center for Extreme States of Matter, which in 2009 received a \$8.2 million contract award from the Department of Energy. According to a Nov. 2, 2009 University of Rochester press release, Dr. Betti testified before Congress "touting recent achievements on the path to making fusion energy ....a reliable, plentiful, and efficient source of energy, and emphasizing the importance of the government's continued support of fusion research. " He was recently awarded the Edward Teller Medal for his research into laser driven fusion at the University's Laboratory for Laser Energetics (LLE), a major NNSA National Ignition Campaign (NIC) contractor, where he holds the post of Assistant Director for Academic Affairs.

Dr. Robert L. Byer, Director of the Ginzton Laboratory at Stanford University and one of the nation's foremost laser scientists, has a long history of supportive involvement with the ICF laser program at LLNL. He was a member of *Livermore's Directed Research and Development Program Subcommittee* from 1992-95; a member of the *NIF Laser Subcommittee of DOE's Inertial Confinement Fusion Advisory Committee (ICFAC)* in 1994; a member of the NRC's controversial and overtly biased *Committee for the Review of the Department of Energy's Inertial confinement Fusion Program* in 1996-97, and a member of the *LLNL Director's Advisory Committee* from 1996-1999, the years in which the NIF construction program was established and laboratory management lied to the Secretary of Energy regarding the projects technical progress and cost; a member of the *National Ignition Facility Programs Review Committee* in 2000, the year the NIF construction project fell apart and the entire project had to be "rebaselined," nearly tripling the laser construction project cost to from \$1.2 to \$3.5 billion; a member of the *Secretary of Energy Advisory Board NIF Laser Task Force*, 1999-2000; and a member of the *National Ignition Facility Advisory Committee*, 2000-present, apparently an LLNL-sponsored body. Given this extensive record of involvement in committees that have endorsed and more often rubberstamped the NIF Project at LLNL, an objective observer could easily be forgiven the observation that Dr. Byer might have difficulty taking a fresh, objective view of NNSA's \$8-\$10 billion "campaign" to achieve ignition in the NIF.

Dr. David Hammer, Cornell University, has a very brief biography on the Academy website that strongly suggests he is or has recently been a consultant to Sandia National Laboratory's high energy density physics program funded by the study's sponsor – "he also researches HEDP using the dynamics of fine wires exploded by short high current pulses....he has been a consultant to several corporations and government laboratories."

Mr. Joseph Hezir is currently and has been for many years a paid lobbyist for the U.S. nuclear industry, representing such clients as the Nuclear Energy Institute, the US Enrichment Corporation, the Edison Electric Institute, Entergy, and Constellation Energy. While he does not appear to have a direct financial conflict that bears on the functions to be performed by the committee, one of his clients, the nuclear energy trade association NEI, represents and lobbies on behalf of numerous member entities that also have a financial and policy stake in DOE's fusion energy research program, including commercial contractors, US national laboratories, and universities. The expertise Mr. Hezir brings to the committee is unclear. He does not appear to have the scientific background to exercise genuinely independent technical judgment regarding the issues before the committee, and therefore seems likely to defer to the technical judgments of those named above who do have such expertise. Hence what he adds to the committee's balance and ability to carry out its functions fairly and impartially is also unclear.

Dr. Kathryn McCarthy is Deputy Associate Laboratory Director, Nuclear Science & Technology Idaho National Laboratory, a DOE national laboratory with fusion energy research activities. Her brief bio on the Academy website is very dated, listing her as "director of Nuclear Science and Engineering at the Idaho National Engineering and Environmental Laboratory," a name which is no longer used. Her conflict of interest is evident. INL's Fusion Safety Program focuses on the technology of fusion reactor materials,

plasma and tritium interactions and characterization and transport of dust. This work is performed in support of the Department of Energy (DOE) Office of Science national fusion energy program and the International Thermonuclear Experimental Reactor (ITER). Dr. McCarthy's employer is actually Babcock and Wilcox, which manages the nuclear energy programs of INL as part of a consortium led by Battelle.

Dr. Lawrence T. Papay, is currently the principal of a management consulting firm with unnamed clients "in electric power and other energy areas," and he has a long employment history with contractors to DOE's National Nuclear Security Administration, which funds the ICF National Ignition Campaign and the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory. From 2000-2004, Dr. Papay was a Sector Vice President for Integrated Solutions responsible for "dealing with the integration of technology in the energy, environment, and information areas for a variety of governmental clients" including DOE. SAIC is a contractor to NNSA, the largest funder of ICF research. From 1991-1999, Dr. Papay was Senior Vice President and General Manager of Bechtel Technology and Consulting. Bechtel is a major contractor to DOE and a partner with the University of California, Babcock and Wilcox Co, Battelle, and the Washington Division of URS Energy Corp in managing LLNL, where the bulk of NNSA's ICF research is conducted. Battelle, it should be noted, also leads a contractor consortium that manages INL for DOE that also includes Babcock and Wilcox, which in turn manages the Y-12 nuclear weapons production complex for NNSA.

Dr. Papay has been a member of: the *Secretary of Energy's Laboratory Operations Board*; the *Secretary of Energy Advisory Board (SEAB) panel on Fusion Energy* and its *Task Force on the National Ignition Facility* (which played a key role in rescuing the NIF project in 1999-2000), and a *PCAST Task Force on Fusion Energy*. Given this resume, the independence of Dr. Papay's views from those of the DOE sponsor and the interests of its contractor community may reasonably be open to question.

Dr. Ken Schultz is a project manager at General Atomics Corp, a major ICF program contactor. For 15 years (1975-1990) managed GA's Fusion Technology Development Department, and from 1990 to 2001, he was "a founding Director of GA's Fusion Technology Division, directing a staff of 50 on DOE's Inertial Confinement Fusion Target Fabrication Project." From 2000 to 2009, he was "Operations Director of the Energy Group, with oversight responsibilities for the Fission, Inertial Fusion, and Photonics Divisions." Given this resume, the independence of Dr. Schultz's views from those of the DOE sponsor and the interests of its ICF contractor community may reasonably be open to question.

Mr. Adrian Zaccaria, is vice chairman and director of Bechtel Group, Inc. As previously noted, Bechtel is the principal co-manager of LLNL, where the bulk of current U.S. ICF research is concentrated. From 1995 to 2008, Mr. Zaccaria was Bechtel's president and Chief Operating Officer, the period in which Lawrence Livermore National Security LLC was formed and assumed management of the lab and the NIF Project. He is not a fusion energy scientist or a physicist by training, and is not technically qualified to evaluate the merits of comparative IFE approaches. Given Bechtel's role in directly managing LLNL and its multi-billion dollar stake in ICF, his presence on the committee would seem to pose an obvious conflict of interest that would appear, on its face, to disqualify him.

Drs. Cowley, UKAEA, Tombrello, CalTech; Whyte, MIT; Wurtele, UCB; Sessler, LBL; Sheffield, UT Knoxville; and Yang, EPRI; appear not to have any obvious conflicts, but neither by professional experience nor institutional affiliation do they seem likely to offset the financial conflicts and longstanding career ties that characterize 12 of the 21 members (57%) of the committee, as outlined above.

While seemingly free of direct ties to LLNL, the NIF project, or the NNSA's existing ICF program, Drs Wurtele, Whyte, Tombrello, and Sessler, are U.S. physicists who have specialized in areas (e.g. particle

beams, lasers, laser-plasma interactions, plasma-surface interactions) that are closely related to fusion energy research), and Drs Whyte, Cowley and Sheffield have been participants in the international magnetic fusion research effort. With the possible exception of Dr. Cowley, who currently works in the U.K., the institutions with which these scientists are affiliated are almost certainly recent and/or current recipients of DOE fusion energy or nuclear energy research funding.

The remaining two members of the committee do not appear to effectively balance it because their interests and backgrounds are somewhat orthogonal to the functions to be performed by the review. Dr. Franklin Chang-Diaz is a former NASA astronaut turned private developer of plasma propulsion systems for future “space tug” missions and eventual travel to Mars, via his small R&D firm, the Ad Astra Rocket Company, located in Webster Texas, near the Johnson Space Flight Center. His last contact with the fusion energy program appears to have been in 1979, when he developed a “novel concept to guide and target fuel pellets in an inertial fusion reactor chamber.” Dr. Chang-Diaz would appear to have a forward-leaning visionary cast of mind well-suited to endorsing the technical prospects for IFE, but not well suited to subjecting them to critical examination, looking to uncover what could be fatal flaws in the vision.

Dr. Jan Beyea by reputation has a versatile and inquiring cast of mind and appears to be the token “independent analyst” and skeptic added to an otherwise biased committee in order to balance it. While Dr. Beyea’s participation is certainly welcome and he brings relevant expertise in energy systems analysis, he is not an expert in either IFE energy systems or the underlying science behind laser or ion beam driver technologies, or the complex and partially classified physics of indirect-drive target implosions. It is an unfair expectation for him to bear the burden of obstructing consensus in what would otherwise appear to be a fairly harmonious and “supportive” group that is well attuned to the study sponsor’s need for an affirmative report that will endorse early development of a DOE- IFE demonstration program, to run in parallel with NNSA’s quest to demonstrate fusion ignition in the NIF, (now entering its 14<sup>th</sup> year at a cost in excess of \$5 billion dollars and a “run-rate” of some \$450 million per year).

In sum, the provisional membership of the Committee is sorely in need of being rebalanced and broadened with the participation of several scientists who are more likely than the current members to bring an independent and skeptical bent to what they will likely hear regarding recent “dramatic progress” in the field of IFE.

The committee is also missing expertise in evaluating the proliferation consequences of continued IFE development in the U.S. and abroad, and the potential utility of training in IFE code development and use for clandestine or overt programs to develop thermonuclear weapons. Here, not intended to be exhaustive, is a short list of names to consider:

Dr. Richard L. Garwin , IBM ret., physicist, needs no introduction.

Dr. Frank von Hippel, Princeton University – physicist, needs no introduction, a preeminent analyst of nuclear fuel cycle , energy, and nonproliferation issues.

Dr. Thomas Cochran, Senior Scientist, NRDC – physicist, current member of the Secretary of Energy’s Nuclear Energy Advisory Committee, background in health physics, brings considerable nonproliferation expertise and deep knowledge of fission energy systems that would compete with fusion power plants.

Dr. Stephen Bodner, retired, former head of the NRL Fusion Program, a leading critic of LLNL’s “shut-up and build it” approach to fusion ignition, former member of DOE’s ICFAC in the 1990’s and a more recent JASON NIF status review, an ICF practitioner whose concerns and warnings have been validated by

events, unlikely to serve given the current predictable make-up of committee, but worth asking nonetheless.

At LANL ICF/Weapons Program: Erick Lindman, Rod Schultz, Charles Cranfill (some of these gentlemen may now be retired. I have been out of this world for a long time.)

John Rowe, Chairman, Exelon Corp, understands the economics of large-scale nuclear power generation and sensitivity of same to competitive electricity markets.

Dr. Matthew McKinzie, NRDC, physicist – brilliant and versatile younger scientist with a keen understanding of the use of unclassified computing tools and experiments and their relevance to nuclear weapons proliferation. Not an ICF expert, but a very quick study.

Dr. Arjun Makhijani, physicist, a principal author of the landmark Ford Foundation energy study “A Time to Choose” in the 1970’s and more recently (2007) “Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy,” and hundreds of publications in between. Widely respected independent expert on radiation and health, nuclear waste disposal, energy economics, nuclear nonproliferation, and disarmament.

At LLNL: Dr. [named supplied to committee] – an expert on proliferation implications of unclassified ICF codes and experiments for nuclear weapons development.

There are undoubtedly numerous other suitable candidates not known to me. I do note the dearth of younger and mid-career scientists on the provisional committee, and think that is regrettable. Each of the above named persons will likely know of others who might have an interest in serving on the committee, if they themselves are unable to do so.