NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

Division on Engineering and Physical Sciences
Board on Energy and Environmental Systems
Board on Physics and Astronomy

Proposal for an Assessment of
Fusion Target Physics

INTRODUCTION

Statement of Task
A Panel on Fusion Target Physics ("the Panel") with access to classified information as well as controlled-restricted unclassified information will serve as a technical resource to the Committee on Inertial Confinement Energy Systems ("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.

This proposal requests $386,313 from the United States Department of Energy (DOE) to support the Panel for an 18-month study addressing the above. Preliminary plans for the proposed study are given below. A separate proposal requests funding from DOE to support the Committee's study.

BACKGROUND

The energy produced by nuclear fusion has the potential to provide a low-carbon, base-load source of electricity; however, significant scientific and engineering efforts are still required before the feasibility of a commercial fusion plant can be established. Concepts for initiating fusion based upon magnetic confinement and inertial confinement of the fusion plasma have been studied for decades. In inertial confinement fusion (ICF), a driver delivers energy to the outer surface of a pellet of fuel (typically containing a mixture of deuterium and tritium), heating and compressing it. If the target physics and driver performance are sufficiently controlled, and other characteristics are adequately understood and controlled, this process will create a fusion chain reaction that yields more energy than that incident on the fuel from the driver. This state is known as "ignition."

There are multiple concepts for delivering energy to the target pellet. Drivers can be in the form of lasers, particle beams, or x-rays. These concepts have very different operating conditions and characteristics. The construction of the target chamber is a significant materials problem and depends on the driver and pellet technologies used. Understanding the strengths and weaknesses of each approach is central to the effort to develop IFE as a power source.

Over the next several years, experiments will be ongoing at the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory that may achieve ICF ignition and propagation burn. This initial demonstration of ignition would be a critical milestone and demonstration of "proof of principle" of ICF. This milestone will need to be achieved for any serious consideration of how an inertial fusion energy (IFE) power plant could be designed based on the energy produced from ICF. At the same time, experiments such as those at the University of Rochester's Laboratory for Laser Energetics, the Naval

Research Laboratory, and Sandia National Laboratory's Z Machine continue to advance our understanding and control of inertial confinement fusion using different technology and target physics approaches.

Given the current level of activity in ICF research, now is an appropriate time to consider how to proceed regarding inertial fusion as a potential power source. An NRC committee and panel will be formed to provide findings and recommendations to advise DOE on the development of an R&D roadmap for inertial fusion energy.

All the approaches to ICF will require much investigation and will need to be considered in any long-term R&D strategy. These include different concepts for the driver (e.g. heavy ions, lasers, z-pinch), the target chamber (e.g. dry wall, thin-liquid, thick-liquid), and the target (direct and indirect drive). At this time, it is not clear whether any of these approaches can lead to a successful IFE demonstration. Therefore, an assessment of ICF concepts is in order.

With this assessment of ICF concepts in-hand, a reasonable approach would be to define a suite of component technologies with the highest likelihood of success, develop them to a suitable level of maturity, and then select a mainline approach toward building and operating for several years a small-scale technology demonstrator based upon progress. Such a device should be the smallest device that incorporates all the major elements of a full-scale machine and is sufficiently large to serve as a basis for scaling up the technology and extrapolating the cost and performance to a machine that could attract commercial investment. Such a technology demonstration plant would need to prove inertial fusion's potential as a stable and reliable source of power and provide enough operating experience to build confidence in the ability to reach commercial scale. Further work would still be needed after this point to achieve a viable and economically attractive commercial IFE system.

PROPOSED STUDY

Scope & Process

The NRC study will have two components. The Committee on Inertial Confinement Energy Systems, composed of about 14 members, will be convened to assess the prospects for inertial confinement fusion energy systems. The Panel on Fusion Target Physics, composed of about 6 members and 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 on Fusion Target Physics will prepare a report that will assess the current performance of fusion targets associated with various ICF concepts in order to understand:

1. The spectrum output;
2. The illumination geometry;
3. The high-gain geometry; and
4. The robustness of the target design.

The Target Physics Panel will also produce periodic, internal, progress reports consisting of only unclassified information that will be provided to the Committee on Inertial Confinement Energy Systems.

The Panel on Fusion Target Physics will begin its work at the outset of the study by assessing the current performance of fusion targets. Once it receives guidance from the Committee on the engineering

parameters of potential IFE systems capable of harnessing the energy released by the fusion reactions for power production, it will identify the challenges that must be overcome to provide the performance needed for a commercial inertial fusion energy system as specified by the committee. The Panel may also consider issues associated with the potential carryover of classified information to commercial IFE system operation.

The Panel will meet approximately 6 times to review work on the target and visit associated facilities where it can collect relevant information. The first three meetings will be used to assess the current performance of ICF targets and develop a report containing only unclassified information to be submitted to the Committee. The first meeting will be used for discussion of the task, initial briefings, and input on the current status of ICF targets; identification of issues; and assignment of write-ups on the various issues. The second meeting will be used to write and review drafts and to discuss findings related to the state of the art. The third meeting will be used to prepare input for the Committee. The last three meetings will be used to address the specific IFE system parameters specified by the Committee as they pertain to target physics issues. The Panel may need additional meetings since it will need to work in a classified environment for information collection and report production, which can take substantial resources and require extra travel for panel members since working outside the NRC's secured facility will be constrained. The Panel on Fusion Target Physics members will not meet with the Committee and the two will not meet at the same time and location.

Access to Classified Information
To fully understand the relevant scientific and engineering challenges associated with fusion targets, access to classified information at the level of SECRET/Restricted Data may be required. To address this, the Panel on Fusion Target Physics that will be separately appointed will be composed of individuals qualified to access such classified information. The panel may also need access to unclassified controlled-restricted information, similar to what the committee may require as noted above. All members of the Target Physics Panel will be cleared at the DOE “Q” level, and this panel will have a separate task order from the main committee.

The Panel on Fusion Target Physics primary task is to serve as a resource to the Committee on Inertial Confinement Energy Systems, responding to requests for information on IFE targets from the Committee. In addition, the Panel may produce annexes to the Committee's final and/or interim reports consisting of only publicly accessible information. The panel has no intention, a priori, of producing a classified document. If classified information is needed in a document in order to justify the Panel's conclusions for the purposes of NRC's institutional review process, a classified document would be produced internally for the review process. Any final document produced would contain only publicly available information (no classified or otherwise controlled-restricted information would be included). The progress report submitted to the Committee just prior to the Committee's interim report may be included as an annex in the interim report.

To avoid contaminating the Committee's work with classified information generated by the Panel, direct interaction between the Committee and Target Physics Panel, with the exception of the Committee leadership (see “Membership”), will be avoided. Therefore, all communication from the Committee to the Target Physics Panel will go through NRC staff to ensure that the necessary procedures are followed. Communication from the Target Physics Panel to the Committee will undergo a security review by an Authorized Derivative Classifier (ADC) to ensure they are unclassified before being distributed to the Committee by the NRC staff.

Membership
The Panel on Target Physics will be composed of about 6 individuals with expertise in fields such as physics, materials science, analytical codes for fusion systems, and nuclear engineering. Because of time

constraints, the NRC will not be able to consider anyone who does not already hold an active Top Secret clearance. With the exception of the Committee leadership, Panel members will not sit on the Committee nor will Committee members sit on the Panel. Members from the National Academy of Engineering and the National Academy of Sciences will be sought for membership on Panel. Individuals will also be sought to provide a balance of industrial, academic, national laboratory and other experience.

The Committee's chair may be appointed prior to the constitution of the entire committee in order to assist with composing the Committee and to provide any needed final guidance on the scope of work for the separate Target Physics Panel. The NRC intends to identify a Committee chair who can also serve as a member (not as chair) of the Target Physics Panel so that there is additional interaction between the two bodies.

REPORTS

The interim and final reports of the Committee on Inertial Confinement Energy Systems may include an annex produced by the Panel on Fusion Target Physics consisting of only publicly accessible information. The Committee's final report will be delivered within 21 months of the study's initiation. The Panel's reports to the Committee will be subject to a classification review by an Authorized Derivative Classifier (ADC) to ensure they are unclassified. The panel has no intention, a priori, of producing a classified document.

The report's primary audience is the Department of Energy. The secondary audience is Congressional staff; Congressional committees; the research community, the technical community, policy leaders, and the general public.

SECURITY REQUIREMENTS

The Panel on Fusion Target Physics will require access to classified information at the SECRET/Restricted Data (SRD) level and will also require access to other controlled-unclassified information that is exempt from public disclosure as described in 5 U.S.C. § 552(b) i.e., exemptions under the Freedom of Information Act (FOIA). The sponsor will coordinate with the responsible NRC staff to provide this access in accordance with NRC procedures for the receipt, handling, and disposition of such information. NRC staff will ascertain as early as possible from the sponsor the need for and nature of controlled-unclassified information for the study and will confer with the Office of Security and the Office of General Counsel before any classified or otherwise controlled information is distributed to the Panel. In addition, DOE Form 470.1, "Contract Security Classification Specification (CSCS)," will need to be included with the contract.

FEDERAL ADVISORY COMMITTEE ACT

The Academy has developed interim policies and procedures to implement Section 15 of the Federal Advisory Committee Act, 5 U.S.C. App. § 15. Section 15 includes certain requirements regarding public access and conflicts of interest that are applicable to agreements under which the Academy, using a committee, provides advice or recommendations to a Federal agency. In accordance with Section 15 of FACA, the Academy shall submit to the government sponsor(s) following delivery of each applicable report a certification that the policies and procedures of the Academy that implement Section 15 of FACA

have been substantially complied with in the performance of the contract/grant/cooperative agreement with respect to the applicable report.

PUBLIC INFORMATION ABOUT THE PROJECT

In order to afford the public greater knowledge of Academy activities and an opportunity to provide comments on those activities, the Academy may post on its website (http://www.national-academies.org) the following information as appropriate under its procedures: (1) notices of meetings open to the public; (2) brief descriptions of projects; (3) committee appointments, if any (including biographies of committee members); (4) report information; and (5) any other pertinent information.

ESTIMATE OF COSTS

The estimated cost of supporting the effort described above during the period April 1, 2010 to September 30, 2011 is $386,313.

Attachment: Detailed Estimate of Costs