

*National Research Council Assessment
- Prospects for Inertial Fusion Energy*

Background for NRC Inertial Fusion Energy Assessment

Ronald C. Davidson and Gerald Kulcinski, Co-Chairs, March 8, 2011

Concepts and Technical Challenges for Inertial Fusion Energy

▶ **Driver**

- ▶ Lasers, heavy ions, pulsed power, other approaches, --- .
- ▶ Requires high repetition rates and heat handling capabilities.

▶ **Ignition**

- ▶ Hot spot versus fast ignition.
- ▶ Indirect versus direct drive.
- ▶ Understand underlying high energy density (HED) physical processes.

▶ **Chamber**

- ▶ Tritium handling.
- ▶ Capsule injection and manufacturing.
- ▶ Significant neutron bombardment.
- ▶ Wall materials and design.

▶ **Implementation**

- ▶ Environment and safety.
- ▶ Cost competitiveness.
- ▶ Public acceptance.

Committee Structure

▶ **Main Committee**

- ▶ Prepare Interim and Final Reports.
- ▶ Twenty-two technical experts from many of the critical science and engineering sub-fields.
- ▶ A twenty-one-month study is envisioned.
- ▶ Provide parameters to the Target Physics Panel.

▶ **Target Physics Panel**

- ▶ Seven technical experts in target physics.
- ▶ Panel Chair will provide periodic progress reports to the Main Committee.
- ▶ Eighteen-month study.
- ▶ Access to classified information.

Committee Membership: Acquiring the Right Balance

- ▶ **The technical expertise of the committee members covers a broad range of sub-fields:**
 - ▶ Plasma physics
 - ▶ Fusion physics & engineering
 - ▶ Fusion (inertial and magnetic)
 - ▶ Radiation physics
 - ▶ Materials science & engineering
 - ▶ Nuclear engineering
 - ▶ Mechanical engineering
 - ▶ Laser systems
 - ▶ Beam systems
 - ▶ Heat transfer
 - ▶ Central station power plants
 - ▶ Non-proliferation
 - ▶ Electric utility industry
 - ▶ Economics
 - ▶ Energy policy
 - ▶ Safety & environment
 - ▶ Construction of large-scale energy systems

Committee Membership

Ronald C. Davidson, *Co-Chair*, Princeton University

Gerald L. Kulcinski, *Co-Chair*, University of Wisconsin, Madison

Charles Baker, University of California, San Diego [Retired]

Roger Bangerter, E. O. Lawrence Berkeley National Laboratory [Retired]

Riccardo Betti, University of Rochester

Jan Beyea, Consulting in the Public Interest

Robert L. Byer, Stanford University

Franklin Chang-Diaz, Ad Astra Rocket Company

Steven C. Cowley, United Kingdom Atomic Energy Authority

David Hammer, Cornell University

Joseph S. Hezir, EOP Group, Inc.

Kathryn McCarthy, Idaho National Laboratory

Lawrence T. Papay, PQR, LLC

Ken Schultz, General Atomics

Andrew M. Sessler, E. O. Lawrence Berkeley National Laboratory

John Sheffield, The University of Tennessee, Knoxville

Thomas Anthony Tombrello, Jr, California Institute of Technology

Dennis G. Whyte, Massachusetts Institute of Technology

Committee Membership

Richard L. Garwin, IBM Thomas J. Watson Research Center

Jonathan S. Wurtele, University of California, Berkeley

Rosa Yang, Electric Power Research Institute, Inc.

Consultant:

Malcolm McGeoch, *Consultant*, PLEX, LLC

National Research Council Staff

David Lang, *Study Director* and BPA Program Officer

Donald Shapero, Director, Board on Physics and Astronomy (BPA)

James Zucchetto, Director, Board on Energy and Environmental Systems (BEES)

Greg Eyring, Senior Program Officer, DEPS

Jonathan Yanger, Senior Project Assistant, BEES

Erin Boyd, Christine Mirzayan Science & Technology Policy Graduate Fellow

Target Physics Panel Membership: Acquiring the Right Balance

- ▶ **The technical expertise on the Target Physics Panel covers the following sub-fields:**
 - ▶ Target physics
 - ▶ Plasma physics
 - ▶ Inertial confinement fusion physics
 - ▶ Materials science & chemical engineering
 - ▶ Computational physics
 - ▶ Analytical calculations

Target Panel Membership

John Ahearne, *Chair*, Sigma Xi

Robert Dynes, University of California, San Diego

Douglas Eardley, University of California, Santa Barbara

David Harding, University of Rochester

Thomas Melhorne, Naval Research Laboratory

Merri Wood-Schultz, Los Alamos, NM

George Zimmerman, Lafayette, CA

National Research Council Staff

Sarah Case, Senior Program Officer

Greg Eyring, Senior Program Officer, DEPS

LaNita Jones, Administrative Coordinator

Statement of Task (1)

- ▶ **The Committee will prepare a Report that:**
 - ▶ Assesses the prospects for generating power using Inertial Confinement Fusion;
 - ▶ Identifies the scientific and engineering challenges, cost targets, and R&D objectives associated with developing an Inertial Fusion Energy demonstration plant; and
 - ▶ Advises the U.S. Department of Energy on the preparation of an R&D roadmap aimed at developing the conceptual design of an Inertial Fusion Energy (IFE) demonstration plant.
- ▶ **The Committee will also prepare an Interim Report that provides guidance to the DOE in planning elements of the Inertial Fusion Energy R&D program for FY 2013.**

Statement of Task (2)

▶ **Target Physics Panel**

- ▶ Requires access to classified target physics information.
- ▶ Will inform the Main Committee on the relevant target physics issues.
- ▶ The major task activity for the Target Physics Panel is to:

“Assess the current performance of various fusion target technologies. Describe the R&D challenges to providing suitable targets on the basis of parameters established and provided by the Committee.”

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▶ Scope of Activities by Main Committee (I)

- ▶ Identify key scientific challenges for achieving a viable inertial fusion energy system and opportunities for using existing facilities to overcome them, as well as where new capabilities will be needed;
- ▶ Identify key engineering and technology challenges for achieving a viable inertial fusion energy system, including an assessment and comparison of component technology maturity and performance (e.g., driver, chamber, energy capture, and target technologies, and balance of plant), as well as technical uncertainties, and timescales associated with the development and demonstration of these components;

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▶ **Scope of Activities by Main Committee (2)**

- ▶ Where practical, conceptual roadmaps will be defined for the most promising concepts for using inertial fusion as the energy source, leading from current capabilities to the achievement of a technology demonstrator. The roadmaps will have success criteria allowing periodic assessment of progress and exit ramps in the event progress is not achieved. The plans will be coordinated as a logical structure for making down-selects as needed.
- ▶ Identify key cost targets for primary commercial plant components, and components that offer the greatest opportunities for cost reduction and pose the greatest cost uncertainties; and
- ▶ Prepare an interim report that will provide initial guidance to the Department of Energy.

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▶ **Scope of Activities by Main Committee (3)**

- ▶ The ***Interim Report*** should identify: Main issues and major component performance roadblocks that will need to be addressed; Major milestones that would have to be achieved; and The plausibility of scale-up for an IFE system.
- ▶ The ***Interim Report*** may or may not include a public annex from the Panel on Target Physics.
- ▶ The Committee will prepare a final report that will address preceding Tasks and include a public annex from the Panel on Target Physics.

Committee Meetings - Present Status

- **Two full meetings have been completed**
 - 1st meeting - Washington, DC - December 16-17, 2010 (DOE leaders, reports on previous studies)
 - 2nd meeting - San Ramon, CA - January 29-31, 2011 (Livermore, Rochester, Sandia, Berkeley, NRL; reports on previous technology work on reactor studies, targets, etc.)
- **One or two more fact-finding meetings before preparing Interim Report**
 - 3rd meeting - Albuquerque, NM – March 30 – April 1
 - 4th meeting – Rochester, NY – June 15 - 17
 - Naval Research Laboratory site visit during future 5th meeting in Washington, DC



Timetable for the Remainder of the Study

- ▶ Start preparing Interim Report in April, 2011 following the March Albuquerque meeting.
- ▶ Discuss/continue preparation of Interim Report at 4th meeting in Rochester in June, 2011.
- ▶ Submit Interim Report to NRC for review in July - August time frame. Determine what additional work needs to be done to complete the Final Report; make writing assignments.
- ▶ Schedule 5th meeting in Washington, DC.
- ▶ NRC review of Interim Report completed and report released - Fall, 2011.
- ▶ Final Report completed by Committee - Spring, 2012.
- ▶ Final Report submitted to DOE - June, 2012.



Thank you for your attention!

Relevant Previous Studies

- ▶ America's Energy Future: Technology and Transformation (BEES, 2009).
- ▶ Review of DOE's Nuclear Energy Research and Development Program (BEES, 2008).
- ▶ Plasma Science: Advancing Knowledge in the National Interest (BPA, 2007).
- ▶ Frontiers of High Energy Density Physics: The X-Games of Contemporary Science (BPA, 2003).
- ▶ An Assessment of DOE's Office of Fusion Energy Sciences Program (BPA, 2001).
- ▶ Review of the Department of Energy's Inertial Confinement Fusion Program: The National Ignition Facility (CPSMA, 1997).