Prospects for Inertial Fusion Energy

Report to the Board on Physics & Astronomy
Ronald C. Davidson, Co-Chair, November 6, 2010
Origin of the Study

- **DOE: Science (Koonin), NNSA (Crandall), Nuclear Energy (Miller)**
  - Provide guidance on long-term roadmap for Inertial Fusion Energy (IFE) systems.
  - Provide Interim Report to inform DOE program directions for FY 2013.

**Motivation for the Study**

- Excitement: Technical results from the National Ignition Facility (NIF).
- Planning: What should the next steps be?
- Feasibility: Is Inertial Fusion Energy technically feasible? What are the showstoppers?
- Community: Unite fusion researchers behind a national plan for IFE?
- Facilities: What are the roles of small-scale and large-scale experiments?

**DOE supports this Study**
Inertial Confinement Fusion (1)

- The “driver” delivers energy to the fuel pellet.
- The pellet is compressed uniformly and quickly.
- A fusion reaction is “ignited”.
- There are several technical approaches for driver, target, and chamber.

LEFT: (top) NIF target chamber  
(bottom) NIF target event rendering
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.

- **Target and Chamber**
  - Tritium handling.
  - Capsule injection and manufacturing.
  - Significant neutron bombardment.
  - Wall materials and design.

- **Implementation**
  - Environment and safety.
  - Cost competitiveness.
  - Public acceptance.
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.
Committee Structure (1)

- **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.
  - Possible access to restricted but unclassified information.
  - Provide parameters to the Target Physics Panel.

- **Target Physics Panel**
  - Six technical experts in target physics; Panel Chair will report to the Main Committee.
  - Eighteen-month study.
  - Access to classified information.
  - Reports to Main Committee by periodic internal progress reports.
  - Possible common member between the two committees.
Committee Structure (2)

Why is the process so complex?

- There is an apparent need to assess classified information for target physics.

- It is not possible to constitute the Main Committee with the needed technical expertise and balance if only Q-cleared members sought for the Main Committee.

- The process necessarily involves many individuals with different levels of access to important technical information.

- A key goal is to balance national security requirements with maximizing the utility of the Panel’s assessment to the DOE.
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.”
Committee Membership: Acquiring the Right Balance

Committee Co-chairs have been appointed: Professors Ronald Davidson (Princeton University) and Gerald Kulcinski (University of Wisconsin).

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
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
Tentative Schedule

- **2010**
  - December: First meetings of the Committee and Panel.

- **2011**
  - February/March: Second Committee meeting.
  - May/June: Third Committee meeting; Preparation of Interim Report.
  - Summer/Fall: Fourth and Fifth Committee meetings; Begin Committee Report preparation.

- **2012**
  - January - April: Committee Report preparation and review.
  - May/June: Release of pre-publication report.
Relevant Previous Studies

- Review of DOE's Nuclear Energy Research and Development Program (BEES, 2008).
- Plasma Science: Advancing Knowledge in the National Interest (BPA, 2007).
Thank you for your attention!
Backup Viewgraphs
Main Committee Activity Areas

1. Identify the key scientific and engineering challenges for achieving a viable Inertial Fusion Energy (IFE) system; identify technical opportunities for optimizing the use of existing facilities, as well as opportunities where new facility capabilities are required.

2. Identify the key engineering and technological challenges for achieving a viable IFE system, including an assessment and comparison of the technical status of the component technologies (e.g., driver, chamber, energy capture, and target technologies, and balance-of-plant), as well as the technical uncertainties, and time-scales associated with the development and demonstration of these components.

3. Develop optimized, conceptual roadmaps for the most promising approaches for inertial fusion energy systems, leading from present capabilities to the achievement of technology demonstration. The roadmaps will identify success criteria based on the periodic assessment of technical progress, and ‘exit strategies’ in the event that technical progress is not achieved. The plans are intended as a framework for making down-selections, as appropriate.

4. Identify the critical cost targets for the primary commercial plant components, and those components that offer the greatest opportunities for cost reduction and pose the greatest cost uncertainties.
Target Physics Panel Activity Areas

- Assess dependence of target performance on the following:
  - Spectrum output.
  - Illumination geometry.
  - High-gain geometry.
  - Design robustness.

- Identify critical R&D challenges that provide suitable Inertial Fusion Energy target design concepts based on top-down engineering parameters provided by the Committee.