A Strategic Plan for U.S. Burning Plasma Research

Fusion Power Associates
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Pathways and Progress Toward Fusion Power
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Mike Mauel, Columbia University, Co-Chair
Mel Shochet, University of Chicago, Co-Chair

http://nas.edu/fusion

Outline

- Background and Origin of Study
- Statement of Task
- Committee Membership
- Schedule and Work Plan of the Committee
- Data Collection used for Interim Report
- Towards completion of the Final Report

CONSOLIDATED APPROPRIATIONS ACT, 2016

PUBLIC LAW 114–113—DEC. 18, 2015

(129 STAT. 2410) That not later than May 2, 2016, the Secretary of Energy shall submit to the Committees on Appropriations of both Houses of Congress a report recommending either that the United States remain a partner in the ITER project after October 2017 or terminate participation, which shall include, as applicable, an estimate of either the full cost, by fiscal year, of all future Federal funding requirements for construction, operation, and maintenance of ITER or the cost of termination.

Study Origin

U.S. Department of ENERGY

U.S. Participation in the ITER Project
May 2016

United States Department of Energy
Washington, DC 20585

Message from the Secretary

- ITER remains the best candidate today to demonstrate sustained burning plasma, which is a necessary precursor to demonstrating fusion energy power.
- Having fully assessed the facts regarding the U.S. contributions to the ITER project, I recommend that the U.S. remain a partner in the ITER project through FY 2018 and focus on efforts related to First Plasma. …
- Prior to the FY 2019 budget submittal (late in calendar year 2017 to early 2018), I recommend that the U.S. re-evaluate its participation in the ITER project to assess if it remains in our best interests to continue our participation.
- My recommendation to support First Plasma cash and in-kind contributions is predicated on continued and sustained progress on the project, increased transparency of the ITER project risk management process, as well as a suite of management reforms proposed in this report …

U.S. Department of ENERGY

U.S. Participation in the ITER Project
May 2016

United States Department of Energy
Washington, DC 20585

Study Origin

National Academy of Sciences Study of the U.S. Fusion Program

- The DOE will request that the National Academies perform a study of how to best advance the fusion energy sciences in the U.S., given the developments in the field since the last Academy studies in 2004, the specific international investments in fusion science and technology, and the priorities for the next ten years developed by the community and FES that were recently reported to Congress.
- This study will address the scientific justification and needs for strengthening the foundations for realizing fusion energy given a potential choice of U.S. participation or not in the ITER project, and will develop future scenarios in either case.

Statement of Task: Two Reports

A committee of the National Academies … will be formed to **study the state and potential of magnetic confinement-based fusion research in the U.S. and provide guidance on a long-term strategy**…

➡ **Interim Report**:

- Describe and **assess the current status of U.S. research** that supports burning plasma science, including current and planned participation in international activities, and describe international research activities broadly.
- **Assess the importance of U.S. burning plasma research** to the development of fusion energy as well as to plasma science and other science and engineering disciplines.

➡ **Final Report:** *In two separate scenarios in which, after 2018,*

(1) the United States is a partner in ITER, and

(2) the United States is not a partner in ITER:

provide guidance on a long-term strategic plan (covering the next several decades) for a national program of burning plasma science and technology research which includes supporting capabilities and which may include participation in international activities, given the U.S. strategic interest in realizing **economical fusion energy in the long term**.

Requirements for two reports…

- Committee appointed through the NAS Board of Physics and Astronomy (BPA) having broad knowledge, appropriate expertise, independent, representative, international
- Extensive information gathering, open and active call for community input, solicitation of expert testimony
- Preparation of written report and findings
- Peer review managed by BPA
- Revision as necessary

Committee Membership

Michael Mauel, Columbia University, Co-Chair

Melvyn Shochet (NAS), Univ Chicago, Co-Chair

Christina Back, General Atomics

Riccardo Betti, University of Rochester

Ian Chapman, UK Atomic Energy Authority

Cary Forest, University of Wisconsin, Madison

T. Kenneth Fowler (NAS), Univ of California, Berkeley

Jeffrey Freidberg, MIT

Ronald Gilgenbach, University of Michigan

William Heidbrink, University of California, Irvine

Mark Herrmann, LLNL

Frank Jenko, IPP, Garching

Stanley Kaye, Princeton University

Mitsuru Kikuchi, National Institutes for Quantum and Radiological Science and Technology

Susana Reyes, LBNL

C. Paul Robinson (NAE), Advanced Reactor Concepts, LLC

Philip Snyder, General Atomics

Amy Wendt, University of Wisconsin, Madison

Brian Wirth, University of Tennessee, Knoxville

David Lang, NRC Study Director

Work-plan and Schedule

- ✓ (June 2017) NAS/D.C.
- • (July 2017) Workshop
  U Wisc-Madison
- ✓ (Aug 2017) NAS/Irvine, CA
- ✓ (Sept 2017) Draft **Interim Report**
- ✓ (Oct-Nov 2017) Peer Review and Revisions
- ▸ (Dec 2017) **Interim Report** Released

- • (Dec 2017) Workshop
  U Texas-Austin
- • FESAC TEC Report
- ▸ (Feb 1-2, 2018) EU
- ▸ (Feb 26-28, 2018) GA
- ▸ (~May/June 2018) PPPL
- ▸ (~Aug 2018) NAS/D.C.
- ▸ (Sept 2017) Draft **Final Report**

➡ Submit input online: http://nas.edu/fusion

Interim Report: Data Gathering

Inputs for the Committee's Deliberations

- Government reports on U.S. participation in ITER.
- Previous reports on burning plasma research and strategy for a burning plasma experiment (7 NRC Reports, 3 PCAST, 1 SEAB Report).
- U.S. DOE fusion strategy reports and annual budget requests (FY2003-17).
- *Many FEAC/FESAC Reports…* (3 FEAC Reports, 16 FESAC Reports)
- Written and oral presentations to the NAS Committee for a Strategic Plan for U.S. Burning Plasma Research.
- Input from the first community workshop on strategic directions for U.S. MFE research, University of Wisconsin-Madison (July 2017).
- *Physical and engineering sciences literature…*
- Expertise of the committee's membership

Interim Report: Data Gathering (1)

U.S. Participation in the ITER Project

- U.S. GAO, *Actions Needed to Finalize Cost and Schedule Estimates for U.S. Contributions to an International Experimental Reactor*, Report to Congress (GAO-14-499, June 2014).
- *Report* ITER Council Review Group (ICRG) Independent Review of the ULTS (April, 2016).
- U.S. Department of Energy, ***U.S. Participation in the ITER Project***, Report to Congress (May 2016).
- *Project Execution Plan for the U.S. ITER SP-1* (Project: 14-SC-60), DOE/OS/FES (January 2017).
- Ned R. Sauthoff, "Perspectives from the U.S. ITER Project," presented to NAS Committee for a Strategic Plan for U.S. Burning Plasma Research (August 29, 2017).

Interim Report: Data Gathering (2)

Strategy for U.S. Participation in a Burning Plasma Experiment, *e.g.*…

- *Pacing the U.S. Magnetic Fusion Program*, chair: Irvin White, National Academy Press (1989).
- *Realizing the Promise of Fusion Energy,* chair: Richard Meserve, Secretary of Energy Advisory Board (SEAB, August, 1999).
- ***Interim Report***, Burning Plasma Assessment Committee (BPAC), (National Research Council, 20 December 2002).
- *Burning Plasma: Bringing a Star to Earth,* chairs: John F. Ahearne and Raymond Fonck, (NRC, Prepublication Release: September 2003).
- *A Review of the DOE Plan for U.S. Fusion Community Participation in the ITER Program,* chair: Pat Colestock (National Academies Press, 2008).

Interim Report: Data Gathering (3)

Fusion Strategy from U.S. DOE

- *Facilities for the Future - A Twenty Year Outlook*, U.S. DOE Office of Science (November, 2003; Updated 2007).
- U.S. DOE fusion annual budget requests (FY2003-17).
- *A Ten-Year Perspective*, U.S. DOE Office of Science, Report to Congress (December 2015); several DOE Workshops, *e.g. Computing at Extreme*, *PMI, Transients, …*

  "The overall mission of the FES program is to expand the fundamental understanding of matter at very high temperatures and densities and build the scientific foundation needed to develop a fusion energy source." - Dr. Patricia Dehmer

- More than a dozen FESAC Reports, including…
  - *Prioritization of Proposed Scientific User Facilities*, chair: John Sarff, (FESAC, March, 2013).
  - *Applications of Fusion Energy Sciences Research - Scientific Discoveries and New Technologies Beyond Fusion*, chair: Amy Wendt, (FESAC, September 2015)

Interim Report: Data Gathering (4)

Community Input

- *Perspectives on U.S. Burning Plasma Research Strategy:*
  Edmund Synakowski (Former Associate Director of Science for FES),
  Emily Domenech and Adam Rosenberg (U.S. House Committee on Science, Space and Technology Science, Space, and Technology),
  Chuck Greenfield and Amanda Hubbard (U.S. Burning Plasma Organization),
  Ned Sauthoff, Bernard Bigot, Stewart Prager, Tony Taylor,
  David Maurer (University Fusion Association),
  Phil Ferguson (Virtual Laboratory for Technology).

- White papers to the Committee; Community workshop on strategic directions for U.S. MFE research, University of Wisconsin-Madison (July 2017).

Interim Report: Data Gathering (5)

Physical and Engineering Sciences Literature

- Members of the committee referenced over 100 published journal articles
  49 *Nuc Fusion, Phys Plasmas*; 33 *Fusion Eng Des, Fus Sci Tech, J Nuclear Mat*

- Eight of the eleven *Nuclear Fusion* Awards were presented to United States scientists working on scenarios, transport, stability, transient control, boundary, and pedestal physics: Tim Luce (2006), Todd Evans (2008), Steve Sabbagh (2009), John Rice (2010), Pat Diamond (2012), Dennis Whyte (2013), Phil Snyder (2014), and Rob Goldston (2015).

- More than 1/3 all articles published in *Nuclear Fusion* have U.S. co-authors

Towards Completion of the Final Report

- Final Report ***technically more challenging*** than Interim Report.
- Committee actively requests scientific and strategic input from community.
- ***Very important:*** Input from the second community workshop on strategic directions at the University of Texas-Austin, December 11-15, 2017, and several site visits.
- FESAC subcommittee will shortly report "the most promising transformative enabling capabilities for the U.S. to pursue that could promote efficient advance toward fusion energy."
- To the extent possible, the final report will include considerations of the health of fusion research sectors within the U.S., the role of international collaboration, the capability and prospects of private-sector ventures, the impact of science and technology innovations, and the research strategies that may shorten the time and reduce the cost required to develop commercial fusion energy.
- Anticipate the final report will present strategies that incorporate continued progress toward a burning plasma experiment, research beyond that done at a burning plasma experiment in order to improve and fully enable commercial fusion power, a focus on innovation, and participation of universities, national laboratories, and industry in the national program.