National Research Council's

Burning Plasma Assessment Committee

Interim Report Summary

R. Fonck for the BPAC
Fusion Energy Sciences Advisory Committee

Gaithersburg, Md

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THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

BPAC Charge

An assessment of a program of burning plasma experiments and its role in magnetic fusion research will be carried out by an NRC study committee. The study will have three components.

- An assessment of the importance of a burning-plasma experimental program to: fusion energy sciences and technology and the development of fusion as an energy source, plasma physics, and science in general.
- An assessment of scientific and technical readiness to undertake a burning plasma experimental program.
- An independent review and assessment of the plan for the U.S. magnetic fusion burning plasma experimental program as developed by the Department of Energy through the FESAC and Snowmass processes. The committee will make recommendations on the program strategy aimed at maximizing the yield of scientific and technical understanding as the foundation for the future development of fusion as an energy source.

Criteria for judging experiments will include the prospects for achieving technical objectives, extracting scientific and technological understanding and making progress of broad and generic applicability, and contributing to the next steps in the experimental program.

BPAC Membership

John F. Ahearne, co-chair, Sigma Xi/Duke University
Raymond Fonck, co-chair, University of Wisconsin
John N. Bahcall, Princeton University
Gordon A. Baym, University of Illinois at Urbana-Champaign
Ira B. Bernstein, Yale University
Stephen C. Cowley, Imperial College London
Edward A. Frieman, SAIC
Walter Gekelman, University of California, Los Angeles
Joseph Hezir, EOP Group, Inc.
William M. Nevins, Lawrence Livermore National Laboratory
Ronald R. Parker, Massachusetts Institute of Technology
Claudio Pellegrini, University of California, Los Angeles
Burton Richter, Stanford Linear Accelerator Center
Clifford M. Surko, University of California, San Diego
Tony S. Taylor, General Atomics
Michael A. Ulrickson, Sandia National Laboratories
Michael C. Zarnstorff, Princeton Plasma Physics Laboratory
Ellen G. Zweibel, JILA, University of Colorado

NRC Staff
Donald C. Shapero, Director, BPA
Michael Moloney, Study Director
Timothy Meyer, Program Associate

BPAC Work Plan - I

- **First meeting held in Washington D.C. on September 17/18 2002**
  - Heard from DOE (Orbach and Davies), OSTP (Looney), ITER (Lackner), FIRE (Meade), IGNITOR (Coppi), Snowmass (Navratil/Sauthoff), FESAC (Pager)
  - Organized approach to letter interim report.
- **Members work between meetings**
- **Second meeting November 18/19 2002, Washington DC**
  - Main focus of second meeting was interim letter report.
  - Heard from OSTP (Marburger), DOE/ITER(Davies & Sauthoff) and Robert Hirsch.
- **Interim report cleared review & submitted December 20, 2002.**

BPAC Work Plan - II

- **Third Meeting Jan 17, 2003**
  - Heard about DOE (Davies), FESAC/Austin (Prager), Fusion Power (Dean), FESAC/35 (Goldston), Restructured Program (Mauel), Tokamaks (Stambaugh), Multimachine (Navratil)
- **Members work between meetings**
- **Fourth meeting to be held in May 2003**
- **Final report is due mid-2003**

Interim Report

- **Addressed two topics**
  - Importance of Burning Plasma for fusion energy
  - Scientific and Technical Readiness to undertake a BP experiment
- **Other relevant issues left to final report**
- **Available at:** *http://www.national-academies.org/bpa* **or:** ***http://www.nap.edu/catalog/10591.html***

Interim Report: Recommendations

- Subject to the conditions listed below, the committee recommends that the United States enter ITER negotiations while the strategy for an expanded U.S. fusion program is further defined and evaluated.

- A strategically balanced fusion program, including meaningful U.S. participation in ITER and a strong domestic fusion science program, must be maintained, recognizing that this will eventually require a substantial augmentation in fusion program funding in addition to the direct financial commitment to ITER construction.

Interim Report: Recommendations (cont'd)

- The fusion program strategy should include cost estimates and scenarios for involvement in ITER, integration with the existing fusion science program, contingency planning, and additional issues as raised in this letter. The United States should pursue an appropriate level of involvement in ITER, which at a minimum would guarantee access to all data from ITER, the right to propose and carry out experiments, and a role in producing the high-technology components of the facility, consistent with the size of the U.S. contribution to the program.

Observations in Text

- "The study of the science and technology of burning plasmas is a critical missing element in the restructured program of the Department of Energy's Office of Fusion Energy Science"

- "The progress made in fusion science and fusion technology increases confidence in the readiness to proceed with the burning plasma step"
  - *See sections on science and technology issues and readiness*

Observations in Text (cont'd)

- Two caveats:
  - …the fusion community is aging and has long range demographic problems.
  - …a technology program without a strong science base, or a science program without a strong technology base, will leave the United States in a position where it cannot build effectively on the developments coming from more advanced programs abroad…
- Potential that "…could be at risk of dropping out of even the "among the world leaders" group …"

Actions in Moving to Negotiations

- Develop an estimated total cost of full participation in the ITER program…
- Analyze several scenarios for U.S. involvement.
- Assess the impacts of U.S. participation in ITER on the core fusion science program, including opportunities to increase international leverage in the core program…
- Develop other options for a burning plasma experiment in case ITER construction is not approved by the negotiating parties.
- Establish an independent group of experts to support the U.S. ITER negotiating team on scientific and technical matters.

Value and Interest

- Scientific importance
  - Nonlinear behavior of confined plasma with self-heating
  - Plasma confinement and stability at large scales
  - Self-heating effects on equilibrium and confinement
  - Alpha particles effects on equilibrium and confinement
  - Operating strategies for energy-producing plasmas

- Technological Importance
  - Behavior & integrity of materials -partial
  - Tritium processing and inventory control
  - High-heat-flux components
  - Blanket design tests - partial
  - Remote handling

Scientific Readiness Issues

- Confidence in confinement projections
- Understanding of operational boundaries
- Mitigation/avoidance of abnormal events
- Ash and impurity control
- Measurement capabilities
- Plasma control techniques

Technical Readiness Issues

- Manufacturing of necessary components
- Component operation in nuclear environment
- Adequate plasma-facing components
- Tritium throughput control
- Remote maintenance
- Fueling, heating, and current drive techniques

Desire Community Input!

- **The NRC BPA committee welcomes input from the plasma and fusion science research community**
  - Any comments, pro or con the proposed BP experiments, are solicited
  - Suggestions for committee issues

- **How to give input**
  - Written comments, suggestions to NRC-BPA via
    - *http://www7.nationalacademies.org/bpa/projects_bpac.html*
    - *E-mail to: burningplasma@nas.edu*
    - *note: all comments received are public access materials*
  - Contact co-chairs or any committee members