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Report of the FESAC Sub-Panel on Potential Roles in Burning Plasma Options

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1.0 Introduction

This Sub-Panel has been asked to prepare a white paper identifying potential U.S. roles in a burning plasma experiment (BPX), considering both international options (e.g., ITER and IGNITOR) and domestic options (e.g., FIRE). For each potential role, the white paper should address topics such as the technical scope and relevance to US capabilities and interests. The purpose was to provide a portfolio of options to facilitate the work of the FESAC Burning Plasma Strategy Panel (BP Panel). The white paper was not intended to address what should be the role of the US in the various options; that is to be the purpose of the BP Panel as a whole. In preparing the white paper, no particular level of overall funding for participation in a BPX was to be assumed. Rather, the white paper should provide a menu of elements for the BP Panel to consider.

The white paper was requested to be ready before the BP Panel meeting in Austin on Aug. 6-8, 2002. A draft of the sub-panel's report should also be available before the Snowmass workshop and should be made available to all Snowmass participants for discussion and feedback.

As a science-based energy program, Magnetic Fusion Energy (MFE) research in the US today comprises four strategic elements as identified by the DOE Integrated Program Planning Activity (Nov. 2000):

1. *Advance the fundamental understanding of plasma, the fourth state of matter, and enhance predictive capabilities, through the comparison of well-diagnosed experiments, theory and simulation.*

2. *Resolve outstanding scientific issues and establish reduced-cost paths to more attractive fusion energy systems by investigating a broad range of innovative magnetic confinement configurations.*

3. *Advance understanding and innovation in high-performance plasmas, optimizing for projected power-plant requirements, and participate in a burning plasma experiment.*

4. *Develop enabling technologies to advance fusion science; pursue innovative technologies and materials to improve the vision for fusion energy; and apply systems analysis to optimize fusion development.*

It is in this context that an assessment must be made. Undertaking a BPX clearly would address Goal 3, the burning-plasma element. Also important is the degree to which this undertaking would contribute to the other three elements, as well, so as best to prepare the program broadly for a subsequent step toward fusion energy. As the U.S. formulates its policy with regard to burning plasma experiments, it is essential to continue to make progress on all four MFE goals. This implies continued, and even enhanced, support for fundamental plasma science, for the investigation of a broad range of innovative magnetic concepts, and for developing innovative materials and technologies for fusion energy.

Progress on each goal has important and mutual benefits for the entire fusion energy science program. Progress on fundamental plasma science improves our understanding of high-performance and burning plasmas and provides predictive tools for innovative confinement concepts. Research on innovative concepts leads to more attractive fusion energy systems and deeper understanding of plasma science. Advancements in materials and technology improve the prospects for attractive energy systems and provide the necessary support for burning plasma experiments.

2.0 Overall Guidelines and Principles for Assessing Potential Roles

The planning and preparation of any BPX initiative must engage a broad segment of the US fusion scientific community to assure significant benefits to both the intellectual development of fusion science in the US and the success of the burning plasma project. US responsibilities and resources would fall into two rather broad areas, those needed to construct and equip the facility and those needed to operate and exploit it scientifically. Benefits derived directly from the former would occur in the nearer term and be more technological in character, although much scientific experience would be gained from the activities required for preparing for operation. Those from the latter would occur in the longer term and be more scientific, although much valuable technological experience would be gained from operation and maintenance of a burning plasma experiment. Among the BPX options currently under consideration -- building FIRE domestically, participating in ITER internationally or supporting IGNITOR in Italy -- the relative share and balance of these two areas of activities borne by the US would vary considerably. In a domestic construction project, the US responsibilities would include nearly the full scope of design, fabrication, installation, testing, and operation. In any shared international endeavor, the responsibilities assumed by the US would span design, construction, operation of equipment and exploitation of the facility, so as to assure maximum continuity and experience-in-depth. The US would not be responsible for the full project. Nonetheless, whatever the final BPX option chosen, it must be anticipated that both types of activities will be undertaken.

Within the area of construction activities, several criteria for US participation can be readily identified:

- building on US experience, strength, and/or leadership;
- maintaining/increasing the breadth and depth of US capability in fusion related technologies; and
- increasing US industrial capacity in high-tech areas, especially ones important to fusion.

Certainly, anything undertaken should support the success of the overall project. If the project is international, similar criteria will likely be adopted by the other parties; in which case, the US can assume that, in part, it will also be accepting some responsibilities that do not necessarily rank high as measured by these criteria but are nonetheless important to the project. For a domestic project, as noted earlier, the US would naturally be responsible for all aspects.

Criteria for programmatic or operational activities include:

- providing opportunity to study burning plasma science under reactor-relevant conditions;
- advancing fusion science or technology in areas important to the US;
- providing scientific experience relevant to other magnetic configurations;
- building on US scientific strengths and providing synergy/continuity with existing US facilities; and
- broadening US expertise by providing opportunities not available on existing US facilities.

Again, for an international project, other parties would likely have similar criteria. As a consequence, the US might expect to lead in some areas and support in others, with data and other information being open to all participants.

3.0 **US Candidate Roles in Burning Plasma Experiments**

A relatively comprehensive list of candidate roles and tasks for the U.S. is given in the attached table. These candidate roles/tasks cover a broad range of potential activities in terms of plasma physics, engineering and technology and they cover potential activities coving all phases of a burning plasma experiment. A brief task description is provided and then each potential task is characterized in several ways.

First, possible contributions to the US plasma science program are identified and they are rated low, moderate or high. A “high” rating means that the task will make a very substantial contribution to the further development of plasma science and related progress towards fusion energy science. Similarly, contributions to U.S. fusion technology are identified and rated in the same manner. A “high” rating here means substantial contributions to the technology required for fusion energy. Finally, the existing US capability to perform the task is rated as high, moderate or low with some brief comments.

Lastly, possible U.S. roles with respect to the three main burning plasma options (ITER, FIRE, and IGNITOR) are described. These roles are only suggestive at this time and would be subject to much further discussion with the project leadership of each option.