Minutes of the Meeting of the Fusion Energy Sciences Advisory Committee (FESAC)

August 1 & 2, 2001
Princeton Plasma Physics Laboratory, Princeton, NJ

Committee Members Present:
Richard D. Hazeltine (Chair)—University of Texas at Austin
Charles C. Baker—University of California, San Diego
Vincent S. Chan—General Atomics
Jill P. Dahlburg—General Atomics
Jeffrey P. Freidberg—Massachusetts Institute of Technology
Joseph A. Johnson, III—Florida A&M University
John D. Lindl—Lawrence Livermore National Laboratory
Kathryn McCarthy—Idaho National Engineering and Environmental Laboratory
William McCurdy—Lawrence Berkeley National Laboratory
George J. Morales—University of California, Los Angeles
Gerald A. Navratil—Columbia University
Cynthia K. Phillips—Princeton Plasma Physics Laboratory
Marshall N. Rosenbluth—General Atomics
John Sheffield—Oak Ridge National Laboratory

Committee Members Absent:
John D. Lindl (August 2)
William McCurdy (August 2)
Joseph A. Johnson, III (August 2)
John Sheffield (August 2)

Ex-Officio Members Present:
Allen H. Boozer (Division of Plasma Physics, American Physical Society)—Columbia University
James F. Stubbins (Fusion Energy Division, American Nuclear Society)—University of Illinois at Urbana-Champaign
Ned R. Sauthoff (Nuclear and Plasma Sciences Society, Institute of Electrical and Electronics Engineers)—Princeton Plasma Physics Laboratory

Designated Federal Officer Present:
N. Anne Davies (Associate Director, Office of Fusion Energy Sciences)—U.S. Department of Energy

Others Present:
Names of guests who were present at the meeting are listed in Appendix A at the end of these minutes.

Tuesday, August 1, 2001

1. Call to Order
The chair, Richard Hazeltine, called the meeting to order at 9:00 a.m. on Tuesday, August 1, 2001. He introduced Dr. James Stubbins, new chair of the American Nuclear Society, as an ex-officio member of FESAC. He welcomed the guests and thanked Princeton Plasma Physics Laboratory for hosting the meeting.

He commented about three actions that FESAC had previously agreed upon: (1) To rotate the location of the meeting at fusion sites—He now thinks that holding the meeting most often in the Washington, D.C., area is

better, with occasional forays elsewhere. (2) To have scientific talks at the FESAC meetings—He wants to continue this. (3) To meet less often—He now thinks that FESAC will meet as often as it needs to.

2. Office of Fusion Energy Sciences Perspective

Anne Davies presented an update about the fusion energy sciences program. Her talk is posted on the FESAC web page (www.ofes.science.doe.gov/More_HTML/FESAC/Presentations8.01/Davies.pdf).

Since the last FESAC meeting, the administration's National Energy Policy Document has been issued. It includes a section about fusion, including the following statement: "The NEPD Group recommends that the President direct the Secretary of Energy to develop next-generation energy sources—including hydrogen and fusion." This document also recommends the development of educational materials about fusion.

Congress is moving along with the budget request for fusion, which is exactly at the level requested. Congress included sympathetic language about the fusion program, stating, however, that funding constraints prevent additional research funding at this time. The Senate had no accompanying language. A House-Senate conference committee is expected to meet in September. Davies said she anticipates that a budget of $248,495,000 would mean the loss of about 100 positions due to cost-of-living increases. The loss of 100 positions will not necessarily mean the loss of 100 people, since some parts of the program (e.g., theory) are highly leveraged with pieces of support coming from various sources. However, personnel will be lost with a flat budget. She noted that this estimate does not take into account the increased cost of electrical power. She is waiting to see whether $25M will be included for laser fusion.

She noted that the House mark-up includes a $2M reduction for the Office of Science budget, whereas none is included in the Senate mark.

She compared the budgets for the various offices within the Office of Science.

She reported about progress in implementing the International Tokamak Physics Activity (ITPA). Substantial progress has been made since her last report about this to FESAC at its February meeting. The first meeting of the ITPA Coordinating Committee will be held in Japan in September to elect a chair and begin its activities. The US and Europe have identified their members for the various ITPA committees. She considers ITPA to be an important process for enhancing US collaboration on burning plasma physics with the world fusion program.

A new agreement has been implemented between the US Department of Energy and the Federal Republic of Germany on dense plasma physics. This agreement establishes a joint bilateral technical program. The collaborative program will be primarily carried out at Gesellschaft für Schwerionenforschung (GSI) in Darmstadt, Germany, which has a heavy ion accelerator.

Another comparative review of plasma theory is underway. One-third (about ten) of the theory grants are up for renewal. Fifty applications were received by July 13. About ten can be funded (for $4M). Sixty reviewers will be involved in the process.

A competitive review of advanced diagnostics development program will occur soon. OFES is looking to revitalize this program in a flat budget scenario. $2.6M is available (but none of it new money), which will be <$400K per proposal. Proposals are due the end of August.

She discussed opportunities for frontier centers in plasma and frontier science. Six white papers have been or are expected to be received, due to the solicitation by the University Fusion Association. Topics of the white papers are: experimental and theoretical investigation of astrophysical plasmas; center for the acceleration of particles in collisionless shocks; a center for magnetic self-organization in laboratory and astrophysical physics; multidisciplinary center on magnetic reconnection; center for energetic ion dynamics; and center for interdisciplinary plasma turbulence studies.

She noted that DOE Under-Secretary Robert Card wants to meet with the chairs of all the advisory committees. The

date for this meeting is yet to be determined. Items that he wants to discuss are: focus and key issues; whether DOE takes advice seriously; recommendations on approach to fusion energy sciences and the biggest opportunities; thoughts on managing science and the DOE role in science; DOE performance compared to that of other agencies; names of other persons with whom to meet and places to visit. He may also meet informally with advisory committee members.

She described the Office of Performance Review (OPR) field review teams. They differ from the Government Performance Review Act (GPRA) in that they are not satisfied with the COSEPUP standards. They use a business-style approach.

She answered questions from FESAC members about her presentation.

3. Report from Theory Review Panel

The chair recused himself during the discussion of the review of the fusion science theory program. Charles Baker assumed the chair at 9:42 a.m.

John Sheffield, chair of the FESAC Theory Review Panel, presented its final report. This report had been revised somewhat after it was first presented at the May 15-16 FESAC meeting. He noted that comments from that FESAC meeting had been incorporated in the present version. Also, useful comments had been received from a number of other persons.

He summarized the revised Executive Summary. He pointed out that the most important finding of the Panel is that the quality, structure, balance, and management of the OFES theory and computing program are, on the whole, good. There have been several notable successes in self-governing community efforts: Transport Task Force (TTF), US-Japan Joint Institute for Fusion Theory (JIFT), NIMROD code development team, and Plasma Sciences Advanced Computing Initiative (PSACI). The Panel recommended several ways in which the program could still be improved, mostly related to whether more formal management is needed (with Panel opinions ranging widely on this point). He listed a number of findings and recommendations.

4. Discussion of Theory Review Panel Report

The chair pro tem (Baker) noted that FESAC has several options: It can endorse the Theory Review Panel's report, endorse it with modifications, or reject it and form a new panel.

FESAC members discussed the report. One suggestion was to replace the word "good" in the principal finding with a stronger endorsement (e.g., the word "excellent"), to prevent any misunderstanding. The enhanced role of the Theory Coordinating Committee, as recommended in the report, was agreed upon; however, it was suggested that the phrase "respond to charges from the OFES" be deleted in the description of the Theory Coordinating Committee role. The meaning of the phrase "NSF peer review model" was thought to be unclear; alternative wording will be provided. In response to a suggestion that support for computing should be increased, the chair pro tem noted that the report explicitly highlights two areas—viz., strengthening theory support for experiments and strengthening advanced computing—in its Executive Summary.

The chair pro tem asked Sheffield to prepare a "final" final version of the report after this meeting, with these suggestions incorporated. (This last and final version of the Theory Review Panel's report is now posted at www.ofes.science.doe.gov/More_HTML/FESAC/Presentations8.01/FINALReport80101.pdf.)

The chair pro tem presented a proposed draft for a letter to Dr. James Decker, Office of Science, responding to the theory review charge. He proposed the statement: *FESAC fully endorses the findings and recommendations of its Panel on the Theory and Computing Program.* After some discussion, FESAC determined on motion to adopt this statement and endorse the revised report of the Theory Review Panel. (The text of this letter is given in Appendix B.)

Hazeltine resumed the chair at 10:56 a.m.

5. OMB View on the NRC Report and the National Energy Policy

Mike Holland, examiner in the Office of Management and Budget who is responsible for the Office of Fusion Energy Sciences budget, talked about the National Energy Policy. He said that he also wanted to receive some feedback from the fusion community about the National Research Council report that had assessed the quality of science in the OFES program.

He noted that in the National Energy Policy report, research has a modest role (only 11 of the 125 recommendations). Fusion gets a nod and some kind words. He interprets this document vis-à-vis fusion as being of little relevance. In his thinking, the NRC Report is more substantial. He considers fusion to be a science program, not an energy program. He does look at OFES performance relative to the energy issue, but scientific progress in understanding fusion plasmas and specific scientific questions is really what he is looking for. The new administration is very focused on performance and getting its money's worth for tax dollars. The administration's view on management is that of performance-based management. For the government's applied R&D portfolio, the question is what are the appropriate investment criteria (which are different for the case when the government is the consumer—e.g., weapons—and the case when it is not.) The Office of Science and OFES should be aware of the Administration's thinking on applied R&D. It intends to develop a separate set of investment criteria for basic research in FY 2004, using the lessons learned during development of investment criteria for applied R&D in FY 2003. He commented that fusion has made a sea change in explaining its program and making a case for itself, but still needs to improve more. OMB is very interested in the Government Performance and Results Act (GPRA), to improve the efficiency and effectiveness of federal programs. NSF and NASA have taken criticism for being vague and amorphous. When asked whether this has to do with the nature of scientific research, he replied that it is easier for the Office of Science when it describes the building of large facilities and the operating of large scientific programs. Asked to give an example of a scientific program that has done well according to GPRA, he said that he had not seen one. (Davies mentioned the human genome program as a good example.) He stated that the COSEPUP standards are sensible. They provide a language that the community can use for talking with outside bodies, such as OMB. The problem is when one reads what the agencies submit in terms of strategic plans. Even the performance plan for the human genome project is not written in a terribly compelling way. He cited the NSF in mathematics and the NSF in materials science as two examples of international benchmarking studies. His reading of the new Administration after eight months is that performance assessment issues will become increasingly important. A program needs to be able to make its case by saying what its mission is, what it has accomplished, and why its achievements are significant.

He described the structure of the Executive Office of the President, noting which agencies are primarily career staff, which are staffed heavily by detailees, and which are staffed by political appointees. OMB consists primarily of career staff, and OSTP consists primarily of detailees. To get anywhere, a program must be on the radar screen of the agencies that consist of political appointees.

When asked about the Integrated Program Planning Activities report of FESAC, he replied that he had read it, but found it impenetrable to a non-expert. He said that he had not yet seen the brochure version of the IPPA report.

He listed proposed R&D investment criteria: (1) Projects support an area identified by the President as a high priority. (2) Projects support work where the private sector cannot capture the benefits of developing the technology due to market failure, and in which there is a clear public interest. (3) Investment in research presents the best means to support the Federal policy goals, compared to other policy alternatives. (4) Projects are subject to a competitive merit-based process, with external review when practical. (5) Project proposals are comprehensive, complete, and include performance indicators and "off ramps" and a clear termination point.

He asked for feedback about the NRC report. The chair responded that FESAC has had several discussions on this and had written a several-page letter that was sent to Dresselhaus's office. This letter gave a detailed response to the NRC report, recommendation-by-recommendation. Also, the chair had given a talk at the NRC about the FESAC response. The chair summarized the FESAC response as positive, namely, that the report was helpful to push our program in a good direction. FESAC had some differences with the report, but mostly about details. The overall focus of the NRC report was healthy.

Holland was asked whether OMB distinguishes between applied science and basic science, in terms of evaluation criteria. He replied that he looks at whether a program has identified scientific questions and whether it has made progress in answering these questions. Whether or not to focus on energy is a policy decision; he assesses whether the fusion energy sciences program meets its scientific goals. He is looking to "buy science." He gauges on the basis of how our program is getting to where it wants to go, on the basis of what tools are available, and so forth.

Asked whether the President has set emphases on certain science areas, he replied that the stated presidential priority is to double NIH funding. Other priorities are to continue with the information technology investments of the former Bush and Clinton administrations and to follow the nanotechnology initiative. He said that he still interprets these as tentative signals, because there has been no clear statement of priorities yet.

6. Recess and Reconvene

The chair recessed the meeting at 12:00 a.m. for lunch. He reconvened the meeting at 1:00 p.m.

7. NSTX Confinement and Heating

Ed Synakowski, Princeton Plasma Physics Laboratory, presented a scientific overview about confinement and heating in the National Spherical Torus Experiment (NSTX), in particular assessing the physics of high beta and low aspect ratio.

8. Overview of Compact Stellarator Program

David Anderson, University of Wisconsin, presented an overview of the compact stellarator program. He described the world stellarator program, including the LHD, CHS, and W7X experimental facilities. The US compact stellarator program includes configurations that have magnetic field symmetry in the toroidal direction (NCSX), helical direction (HSX), and poloidal direction (QPS). The US has had a leadership role in worldwide 3-D theory and modeling; in fact, international efforts have drawn heavily on these tools in developing stellarator optimization codes. The US program has two Concept Exploration-level experiments: HSX (at the University of Wisconsin), which has quasi-helical symmetry and low-collisionality electron transport, and CTH (at Auburn University). There are two new proposed projects: NCSX (low collisionality transport, high beta stability, quasi-toroidal symmetry, low aspect ratio), which would be at the Proof of Principle level; and QPS (quasi-poloidal symmetry at very low aspect ratio), which would be at the Concept Exploration level.

9. Johnson and Lindl Comment

The chair permitted FESAC members Joseph Johnson and John Lindl to comment on the compact stellarator proposal and the Burning Plasma Science Panel's report at this time, since both of them will need to leave the meeting later today due to other obligations.

Johnson: The hesitations in the original FESAC analysis of compact stellarators have been strongly addressed. Hence, we should not change the earlier FESAC recommendation about building a stellarator.

Lindl: There is a need for complex modeling work. This should be sought along with a burning plasma experimental push. Also, a burning plasma experiment should be used as an opportunity for starting a thrust for new diagnostics. Some of the recommendations in the Burning Plasma Science Panel's report will require $1-2M of additional funding. These recommended activities would have to be a priority for people in the field.

10. QPS Physics Validation Review

Harold Weitzner, New York University, who served as the chair of the recent Physics Validation Review Panel for the proposed Quasi-Poloidal System (QPS) experimental facility, summarized the report of the panel.

On April 24 and 25, this panel reviewed the QPS configuration for designation to Concept Exploration status. The project cost is estimated to be $11.5M, with an annual operating budget of $5M. The first plasma operation would be in FY 2006. The reasons why QPS would be so much cheaper than NCSX (by a factor of five) are as follows: (1) The Concept Exploration scope of the experiment, versus being a Proof of Principle-level facility. $B_T R$ is 2.6 times smaller for QPS than for NCSX. (2) The assumption that the site infrastructure would be configured to QPS specifications at the time when the Fusion Energy Division at ORNL moves to its new site.

He listed the advantages and disadvantages of low aspect ratio for compact stellarators. He noted that some scientists feel that there might possibly be a gain in the plasma beta value (up to 10-15%) at low aspect ratio, as with tokamaks. However, others feel that the beta limits have not yet been fully explored. There seems to be some evidence that the ballooning stability limit can be exceeded. On pessimistic assumptions, QPS is designed to get 2.5% volume-averaged beta.

He presented the review panel's assessment:

- The review panel concluded that a reasonable set of coils to achieve QPS has been proposed.
- QPS is one of a family of configurations with quasi-poloidal symmetry. High beta—as much as 10-15%—is possible.
- Its principal scientific goals are: (1) To test improved neoclassical confinement related to quasisymmetry; and (2) To test stability limits. Additional goals are: (1) To explore turbulent confinement and transport; (2) To compare and contrast with other configurations, such as HSX, NCSX, and W7X; (3) To test the bootstrap current prediction; and (4) To test the effects of poloidal versus toroidal quasi-symmetry on plasma flows.
- Concerning the ability of QPS to achieve its goals, the review panel felt that: (1) Adequate power is available. (2) With standard enhancement over ISS95 scaling (enhancement factor of 1.3-1.6), beta of 2-2.5% is plausible. (3) Stability goals can be tested. (4) Concerning transport, at low density the electrons are in the neoclassical regime. (5) Electron neoclassical transport is possible. (6) Other regimes are expected to be dominated by anomalous turbulent transport.
- All panel members agreed with the recommendation that low-aspect-ratio, quasi-poloidal symmetry is an attractive stellarator option.
- A clear majority of the panel members also felt that these properties fully justify proceeding with the QPS project. However, a minority of the panel members felt that since the attractiveness of the configuration is tied to the promise of high beta operation (>10%), the facility should be capable of addressing the question of accessibility to the high beta regime. This means that, if the confinement and low beta limit studies confirm theoretical predictions, and if power upgrades are possible, the QPS plasma configuration should allow such studies. The presently proposed QPS has not been shown to have these properties.

Weitzner summarized the review panel's conclusions concerning personnel and management. If the program goes forward, more mid-career physicists—especially experimentalists—would be needed and should be brought on board promptly. Collaborations must begin to be developed, since they are an essential part of the program.

Concerning the budget, the review panel reached the following conclusions: (1) QPS is at the high-end limit of the Concept Exploration level. (2) It would be possible only with extensive site credits. (3) There would be a long wait for full development of diagnostics. About half of the $5M annual operating budget would be for diagnostics, with the other half for experimental operation. (4) The cost may be under-estimated, although it seems reasonable at this point. (5) Collaborator costs are probably underestimated in the proposal, as there are likely to be greater demands on collaboration than assumed. Finally, the review panel recognized that the OFES decision on whether or not to proceed with this project would be made within the context of priority recommendations by FESAC about a stellarator program.

Weitzner also offered some personal comments about the QPS project.

FESAC members commented on the QPS Review Panel's report. One comment was that, viewed independently, both NCSX and QPS have merits; however, a rationale for doing both has not been presented, other than that they are complementary. Weitzner responded that the reason for wanting to do both is that they are different. The question is whether to do both of them sequentially or simultaneously; this is a programmatic decision. Other comments were that QPS would be too small and collisional to test whether neoclassical will dominate over anomalous transport; and that its experimental budget would be deficient. In particular, Lindl expressed his concern that QPS looks like an under-funded Proof-of-Principle device being presented as a Concept-Exploration class of experiment and that it would be unwise for the fusion program to commit to doing it this way.

Johnson and Sheffield left the meeting at this point.

11. Perspective on Compact Stellarators

Stanley Milora, Fusion Energy Division, Oak Ridge National Laboratory, presented an ORNL perspective on the compact stellarator program.

He pointed out that ORNL has had a long-standing commitment to stellarator research: (1) ORNL has developed design and analysis code tools. (2) ORNL designed, built, and operated the Advanced Toroidal Facility (ATF) stellarator experiment. (3) Low-aspect-ratio stellarator design work at ORNL during the past six years led to the QPS design that has been studied for the last year and a half. (4) ORNL has been an integral partner and has leadership roles in NCSX.

He described the unique research that could be done in the very-low-aspect-ratio QPS experiment: (1) physics not obtainable from other experiments and theory, and (2) study of fundamental issues common to low-beta and high-beta quasi-poloidal configurations.

He noted that part of the reason for the estimated low costs of QPS is the proposed use of University of Tennessee students and outside collaborators. Another factor is redirection of some existing funding.

There would be broad participation in the experimental program. Half of the program budget would be for university and PPPL collaborations. ONRL's share of the experimental program would be about 50%.

He noted that ORNL is planning to move its Fusion Energy Division to a new location, on its main campus. The State of Tennessee will build three buildings for joint institutes (Joint Institute for Computational Studies, Joint Institute for Neutron Sciences, Joint Institute for Biological Studies). The experimental facilities for fusion would be two miles away from the main campus. ORNL offers to provide a $5.1M, 27,500 sq. ft. multi-purpose research facility (65% of which would be used for fusion). Also, 60 office spaces will be provided in a new office complex on the main campus, with additional offices at the experimental facility site. ORNL will provide $4M in infrastructure support, consistent with the QPS device. DOE is expected to bear the cost of relocating the remainder of the Fusion Energy Division hardware and people ($4.35M in FY01 dollars), over 3-4 years.

Davies commented that ORNL has been very creative in being able to get new buildings constructed, in order to renew its infrastructure. ORNL and Battelle have obtained commitments of private sector money for construction, which DOE would pay back over future years.

Lindl left the meeting at this point.

12. Compact Stellarator Cost and Schedule

Rob Goldston, Princeton Plasma Physics Laboratory, gave a presentation concerning the overall cost and schedule of the proposed compact stellarator program, including the NCSX and QPS facilities.

NCSX would cost $58.35M, and QPS would cost $12.152M. (Note: All cost estimates are in FY01 dollars). NCSX would start with 3 MW of power, whereas QPS would start with 300 kW. NCSX diagnostics would cost $2.7M, whereas QPS only $200K, with more diagnostics being paid for out of operating costs in later years.

A stellarator community theory planning workshop, "Future Directions in Theory of 3D Magnetic Confinement Systems," will be held December 3-5, 2001, at ORNL.

He commented that the fragility of flux surfaces is the most interesting physics issue for low-aspect-ratio stellarators (e.g., QPS). Quasi-poloidal symmetry is essentially the same as the symmetry to be investigated by W7X.

He presented a detailed breakdown of incremental costs for the compact stellarator program. He also presented the proposed schedule for construction and operation. He stated that the compact stellarator program would integrate nicely with a tokamak burning plasma experiment.

13. Recess

The chair recessed the meeting at 5:37 p.m. for the evening. He announced that more discussion of the compact stellarator program would be scheduled during tomorrow's session, prior to the Burning Plasma Panel report.

Immediately after the evening recess, FESAC members toured the experimental facilities at Princeton Plasma Physics Laboratory.

Wednesday, August 2, 2001

14. Reconvene

The chair reconvened the meeting at 9:00 a.m. on Wednesday, August 2.

Joseph Johnson, John Lindl, William McCurdy, and John Sheffield were absent today.

15. Briefing from ITER Canada

Peter Barnard, chairman and CEO, ITER Canada, presented the ITER Canada plan to host the proposed International Thermonuclear Experimental Reactor facility. ITER Canada is a non-profit corporation, set up in 1997, with stakeholders from both the public and private sectors.

He reported about recent progress in decision-making on ITER implementation. Canada had previously been a participant in ITER through the European Union, but, now having offered a site, has become a full participant. A formal Canadian government announcement of a site offer was made in June. A Japanese site offer is expected in September, and a European offer in December. A design schedule has been proposed. Draft site evaluations are scheduled for March 2002, with a preferred site to be chosen in June. Nominees for the Director-General would also be available in June 2002. A Final Agreement plan and implementation plane would be put forward in October 2002, with approval of the agreement in December 2002.

He described the Canadian site offer and how it would be attractive to the US fusion community. He noted several advantages of the 400-acre Canadian site at Clarington: tritium on-site availability, ocean-going ship dock access on Lake Ontario, proximity to a major world city (50 km from Toronto) with attractive socio-economic and cultural milieu, public and private sector partnership (including private sector financial discipline), favorable licensing environment. He also noted that Canada, although without a fusion research program of its own, would be a willing host for other countries' fusion research as a neutral site at low cost.

With respect to the overall construction cost of ITER, the participating countries would construct common elements and ship them to site, and their cost would be considered an "in-kind" contribution, so it is difficult to arrive at a realistic number for the overall construction cost of the project

Canada will finance and pay for the host construction obligations. Ontario Province will provide $300M for construction. During operations, ITER Canada will provide electricity, tritium, personnel, and operating/maintenance services at 10% below current ITER budget costs. Direct Canadian contributions (in FY00 Cdn $) would consist of Cdn $1B for the Clarington site, Cdn $1B for buildings and infrastructure, and Cdn $0.8B for operating phase support. The cost savings for using the Canadian site for ITER would be Cdn $10B compared to a Japanese site or Cdn $4B compared to a French site. The construction costs would eventually be paid back to Canada by the research participants through the contract with ITER Canada. He noted that the CANDU reactors, which produce tritium, plan to continue to operate for another twenty years.

The local community within a 50-mile radius is accepting of the nuclear site at Clarington and also another one 50 miles away. A survey was taken, which indicated such support. The decontamination and decommissioning plan has been shared with the community. The plan would be to leave it in place and allow natural decay to occur for as long as 100 years, then dispose of 6000 tons of radioactive material in Canada.

He described the advantages to having the US join the ITER negotiations by the end of this year. Coming in later would be acceptable, but not as helpful. The US could initially come in as observers; ultimately, however, US participation is desired. The key decision in the near future will be site selection

16. Briefing on ITER Status within the Japanese Government

Masayuki Nagami, Japan Atomic Energy Research Institute, presented a briefing concerning the fusion research program of Japan.

He stated that ITER is the core of the present fusion program of Japan. The Atomic Energy Commission of Japan in 1992 established a third-phase fusion R&D program. The three main lines are a tokamak fusion experimental reactor (now designated to be ITER), concept improvement, and long-term technology development. The Japanese government had assigned JAERI to be responsible for ITER EDA and CTA. The three main lines of fusion research at JAERI are ITER, JT-60SC, and International Fusion Material Irradiation Facility (IFMIF). JAERI fusion research activities other than ITER are the JT-60U experiment and modifications to JT-60SC, the JFT-2M experiment, the Numerical Simulation Project (NEXT), reactor studies for various energy applications, and materials development.

He cited some recent highlights of JT-60U research: (1) High normalized beta. (2) "Current hole" due to growth of off-axis bootstrap current in the internal transport barrier layer, which suggests that central current drive is not needed in a tokamak.

He discussed the completion of the ITER Engineering Design Activity (which ended July 21, 2001).

He discussed the construction decision and the proposal to site ITER in Japan. Former Prime Minister Mori is chair of the Forum for Fusion Energy Promotion in the Diet. Three locations within Japan for the ITER site—Hokkaido, Aomori, and Ibaraki—were officially proposed on July 27. The Japanese Atomic Energy Commission set up a Special Committee on the ITER Project, which issued its final report in May 2001. The Atomic Energy Commission endorsed the special committee's report in June. Currently the Council for Science and Technology Policy (chaired by Prime Minister Koizumi) is assessing the ITER project. A decision by the Cabinet Council will be made in September. Internal site selection is being done by a Site Evaluation Committee of the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) and will be completed by the end of August.

17. Discussion of Compact Stellarator Program

FESAC discussed the presentations made yesterday concerning the US compact stellarator program.

The chair asked each FESAC member to comment (see also §9 of these Minutes).

Sauthoff: The COSEPUP criteria will help make a compelling case for the Office of Management and Budget. Overall, the compact stellarator program is an outstanding example of meeting the COSEPUP criteria: viz., high quality, relevance, and opportunity for world leadership. We can sell this to OMB. The program needs a spectrum of sizes and institutions. The high end is NCSX; we need to confirm its previous endorsement. QPS need not be held to the same standards as NCSX, since it is on the Concept Exploration level. QPS serves its own role. The QPS review panel said it is worth doing. It would also serve an important role of keeping ORNL involved in the fusion program. ORNL has institutional strengths to offer.

Navratil: FESAC plays a critical role in the fusion energy science program of not only saying whether something is technically worthwhile doing, but also providing advice to DOE OFES on the relative priorities of elements in the fusion program. I offer my comments on the stellarator program based on my perspective as a member of the FESAC Proof-of-Principle Panel and the Chair of the NCSX Physics Validation Review. I strongly support proceeding with NCSX. The TFTR D&D money will be rolling off and hence become available for doing this project. NCSX is clearly the centerpiece of the compact stellarator program. The compact stellarator program will be able to deliver on the FESAC goals of validating the compact stellarator approach. My view of the QPS proposal is different. It is an interesting experiment, but the cost-to-benefit ratio of this experiment puts it in a lower category in the OFES program. Other devices in the compact stellarator program will address most of its key physics issues: e.g., W7X will study quasi-poloidal symmetry effects in stellarators and NCSX will give us information on

bootstrap current effects in quasi-symmetric stellarators. The compact stellarator program is sound without the QPS device. I share the concerns voiced by John Lindl yesterday that the QPS experiment is an under-funded Proof-of-Principle class experiment and incorrectly carries the Concept Exploration label. The costs of the QPS device and program are significantly understated. Also, there are important programmatic issues that must be taken into account. At the FESAC Knoxville meeting and also subsequently, FESAC has identified some critical under-funded areas in the fusion program. For example, DIII-D and NSTX both have budget shortfalls. For the lack of $3M/year, the NSTX program schedule will slip by two years on key scientific milestones. If we proceed with QPS under the present expectation of relatively flat fusion funding in the next few years, this would necessarily be at the expense of these higher priority elements we have identified in the program. Additionally, ORNL has responsibilities for important parts of NCSX, but has a very limited number of personnel. Proceeding with QPS and NCSX would cause key ORNL scientists who work on DIII-D to be withdrawn in order to work on an experiment at ORNL, damaging the Advanced Tokamak validation work we need to complete by 2004 to carry out the assessment called for in the Knoxville report. Rather than initiating another under-funded experimental project, the budget for DIII-D, NCSX, and other under-funded innovative concept confinement and next-step option elements in the current program needs to grow.

Chan: I endorse NCSX. I urge that studies be continued for extending QPS to higher beta. This is more exciting than the currently projected beta values. All program elements should be prioritized according to the FESAC goals. Funding needs to be considered in the perspective of what are the higher priority elements in program.

Phillips: Regarding QPS, the review panel said that it would be valuable for the program, and I haven't seen evidence to contrary. We haven't been presented sufficient detailed technical information today, so I am reluctant to make a negative recommendation on QPS. I am comfortable with NCSX—the reviews have been positive. The overall compact stellarator program may need more examination, but being negative about the QPS element, based on the information presented today, would make me uncomfortable

Freidberg: I have sympathy with Navratil's points. If one looks at any individual element in the compact stellarator program individually, they all seem interesting. I have a good feeling about NCSX. On a scientific basis, what is the compelling reason for simultaneously doing both NCSX and QPS? They don't seem all that different. There is a problem with funding both experiments. We want the costing for both to be as accurate as possible. Goldston presented numbers, but some of us think these numbers are low. The question is how to fit this into a fixed budget. What is the priority of these experiments relative to the overall program, including a burning plasma experiment and present under-utilized experimental facilities? We ought to have a careful cost evaluation. I think the projected costs are low.

Dahlburg: The complete compact stellarator program is very appealing. I like its significant computational aspect. To make good use of 3-D codes, good diagnostics are needed. NCSX is well planned; it is a nice showpiece for the compact stellarator program. QPS has advantages (university consortia, etc.). I suggest taking next year to do an analysis of QPS—make a chart of where QPS will answer issues, of the diagnostics needed to validate 3-D codes, and of the cost estimates. Make a true evaluation of QPS at the end of the year.

Baker: I have mixed views on the overall question. It is a good program overall, but it needs to be seen in the context of the entire fusion program. The present funding for the technology program is well below that identified at Knoxville. The question is how to allocate within a fixed budget for the total program. What is most important within the compact stellarator program—to which machine should an increase in the budget be applied? We must keep in mind, for the sake of the national program and also to have a viable program at ORNL, that fusion needs to move out of the Y-12 site there. We need to maintain institutions and capabilities. I was confused yesterday about the QPS scientific goals, e.g., the beta limits.

Rosenbluth: I agree with everyone so far. I am most sympathetic to Navratil. The whole program is over-stressed, not making use of facilities, not taking advantage of computational opportunities. There is even a small penny in my heart for technology, as mentioned by Baker. The area of compact stellarators is an exciting area to be in, but I'm not sure if we need to jump in with all four feet at once. It seems to be unanimous that NCSX is the most valuable proposal, albeit also the most costly. We can't afford more than one, and I would pick that one. Dahlburg

made a good point that QPS, with more study, might show that it fills a crucial niche. I received no clear answer about which line has better prospects to get to reactor-level beta values. My judgment, on the basis of the information that has been presented, is that both have about the same ultimate promise at this moment. I urge ORNL to make a more compelling case, to push the case of the relative merits of the two quasi symmetries. It is also true that doing one of them—of which NCSX is clearly the more advanced—will give information about either approach. We have gotten into the position, perhaps inevitable, of having spawned many small non-tokamak experiments. At some point, before starting new ones, we have to think whether we can do without some of the old ones. Is QPS more attractive than other small experiments? Keeping ORNL viable is an important objective. How is this compatible with these other considerations? ORNL has an important role in the technology area. It is also heavily involved in a new SciDAC role with its radio-frequency heating grant. Pellet injection, which will be important for future machines, is a national area for ORNL involvement. We have lots of ideas, but not enough money to pursue them. On balance, we are over-extended at present. Diagnostics is good point; QPS doesn't have enough. QPS would probably be under-funded.

Boozer: DOE should proceed with the compact stellarator program, with NCSX as its major element. A robust computational and theory program for compact stellarators is essential. Theory provides connections among experiments of differing scale and to the world program. The compact stellarator program should be national in scope. The case that QPS would be cost-effective has not been made, nor does its budget appear realistic, in particular the $5M/year for operations, of which half is diagnostics. I agree with John Lindl's statement that QPS is a Proof-of-Principle program masquerading in a Concept-Exploration proposal. Unfortunately, institutional issues have been dominant over scientific issues in the compact stellarator program. The outlook for an effective theory program on stellarators is compromised by the failure for such a program to develop for the spherical torus. No theory leader with a comprehensive view of spherical torus theory has been identified. We do have to worry about institutional issues (e.g., it had been decided to preserve PPPL as the major lab). We want to keep ORNL—but we don't want to have a welfare program. QPS is an important concept. Optimal aspect ratio is an important issue. But doing an experiment at this time may not be best. Don't assume that NCSX is so conservative that no more theory or computations are needed to make it work well. ORNL is playing—and must play—a critical role in NCSX if it is to be a success. Even if QPS does not go forward, there is plenty of work for ORNL to do as a joint proposer with PPPL of NCSX. I am afraid that QPS will be a distraction, impairing the success of NCSX while being too poorly funded to address its stated mission.

Stubbins: I am not well informed on this subject, but I have received some impressions. The compact stellarator program seems to have good leadership. I am not sure how the marrying of computational issues to the machines: will occur. For that to occur, good diagnostics are needed, as Dahlburg has commented. The issue of how the compact stellarator machines stand alone has not been resolved. What parameter space would be measured in each machine has not been well defined. There is a compelling need to marry the computational and experimental sides.

McCarthy: I understand how the program is strapped. But I remember Dr. Dresselhaus saying that we need to give the Office of Science a compelling reason to give us more money. Look at the short-term sacrifices, whether they will help in the long term. Hire the ITER Canada group to help us sell ourselves. We under-appreciate that sort of thing. Mike Holland made it clear that we don't do it well enough. New machines bring in new students and are good for public relations. There is new scientific information to be gotten. Why do we need two compact stellarator experiments at once? Do we need NCSX and QPS in parallel? There is no chart to show why. I am not convinced that we need both in parallel. It is difficult to judge both on the same footing. QPS needs more time. Is it really true that the US would be a world leader if we have both NCSX and QPS? I am not convinced of this. Weigh the short-term pain versus the long-term benefits.

Morales: Stellarators are difficult. If they were easy, we would have been doing them long before. I am concerned about the technical difficulties and the small number of stellarator experts. We need to provide full support for the PPPL proposal. I urge ORNL to participate in this. Seven years from now, we will have a manpower shortage in the stellarator area. The two smaller university efforts nicely complement NCSX. We have to make sure that NCSX succeeds.

Anne Davies also commented. She said that she hears the concerns that were expressed, viz., about priorities and the scientific basis. OFES tries to follow a portfolio approach. The compact stellarator program tries to cover the bases, fill in the holes. She said that she is sensitive to the need for appropriate theory and diagnostics support. Will the opportunity still exist for an experimental program at ORNL in a couple more years? Right now they are moving, and a new building is possible. The opportunity to use ORNL as an institution is coming up shortly. It's true that QPS has been looked at for only six months—but ORNL has been working in this area for over a decade. It is true that QPS may not be able to do all the diagnostics or have all the power the first year—but now time is on our side. People are only asking whether we are doing good science. Doing things more slowly has not been causing us problems in recent years. She mentioned that she is proud that the three main experimental facilities of OFES are at a single-purpose national laboratory (PPPL), a university (MIT), and an industry (GA). This is different from all the other Office of Science programs. The value of having a multi-purpose national laboratory involved in fusion is also high. Hence she listens when ORNL says it wants to move its fusion program. This is not the reason for doing QPS, but it is a strong motive.

The chair allowed the FESAC non-members who had made presentations about compact stellarators to comment.

Weitzner made two points: (1) There is no question that the next major compact stellarator initiative should be NCSX. This has priority. (2) FESAC has raised technical questions about QPS. The Physics Validation Panel studied the same questions, but nevertheless a clear majority concluded that QPS is worth doing. The issues raised will be addressed naturally in the next step of a review. [Anne Davies noted that the Engineering and Cost & Schedule reviews would be next.]

Goldston noted that in his presentation he had given no priority ratings to NCSX and QPS. QPS is an attractive, complementary approach. Its one key research point is the fragility of flux surfaces.

Milora commented that QPS is not a Proof of Principle experiment. It is aimed to look at unique physics in the very-low-aspect-ratio regime. As much as possible, ORNL plans to leverage resources that are available at the laboratory. This leveraging needs to be taken into account in discussions of the cost.

Anderson noted that in his talk, he had tried to address what issues each compact stellarator facility would address. The charge to the US stellarator community had been to devise a program to assess compact stellarators; QPS certainly pushes this to the limit. The compact stellarator program covers all the bases for the purpose of addressing the FESAC goal. Costs are another consideration, of course.

18. Report from Burning Plasma Science Panel

Jeff Freidberg, chair of the FESAC Panel that had been established to address the burning plasma physics charge, presented the final report of this Panel.

He noted that the main issues for a burning plasma are high performance and long pulse. Both imply dollars. High performance will need the following: (1) The achievement of fusion alphas supplying twice as much power as the input power, i.e., Q=10. (2) High plasma temperature and density. (3) Profile control of temperature, density, and current density. (4) Stabilization of macroscopic plasma instabilities. (5) A robust plasma-wall solution.

An overriding science issue in a burning plasma is the nonlinear coupling of basic phenomena, due to the dominance of alpha heating. In particular, the external profile control is much more difficult in a burning plasma, where alpha heating is dominant, than in current plasmas.

Long-pulse operation brings in the following considerations: (1) A fusion energy source will ultimately require steady state or very long pulse operation. (2) A burning plasma experiment should operate with sufficiently long pulses to show progress towards the ultimate goal. (3) How long is long? The pulse length should be measured in appropriate dimensionless units. It is desired to have the pulse length be much longer than the current redistribution time. When asked about the even longer time scale associated with plasma-wall equilibration, Freidberg replied that the Panel hesitated to recommend that money be requested to afford that long a pulse.

Freidberg listed the Panel's main conclusions: (1) We are scientifically and technically ready to proceed to a burning plasma experiment. (2) We are ready now. (3) ITER-FEAT, IGNITOR, and FIRE provide a good range of choice. (4) It is better to devote our efforts to perfecting these options, rather than trying to invent new reactor concepts.

The draft version of the Panel's report included the following findings:

- *Credibility of Fusion as an Energy Option*: A burning plasma experiment is the crucial next step in establishing the credibility of magnetic fusion as a source of commercial electricity
- *The Next Scientific Frontier*: The next frontier in the quest for magnetic fusion energy is the development of a basic understanding of plasma behavior in the regime of strong self-heating, the burning plasma regime.
- *Frontier Physics Issues in a Burning Plasma*: Production of a strongly, self-heated fusion plasma will allow the study of a number of new phenomena depending on the degree of alpha self-heating achieved. These include: The effects of energetic, fusion-produced alpha particles on plasma stability and turbulence; the strong, non-linear coupling that will occur between fusion alpha particles, the pressure driven current, turbulent transport, MHD stability, and boundary-plasma behavior; and stability, control, and propagation of the fusion burn and fusion ignition transient phenomena.
- *Generic Issues in a Tokamak Burning Plasma Experiment*: A burning plasma experiment in a tokamak configuration is relevant to other toroidal magnetic configurations. Much of the scientific understanding gained will be transferable. Generic issues include the effect of alpha particles on macroscopic stability and alpha particle losses, RF and neutral beam heating technology, the methods used to handle edge power losses, particle fueling and removal, and the feedback mechanisms needed to control the fusion burn. Equally important, the experience gained in burning plasma diagnostics, essential to obtaining data to advance fusion plasma science, will be highly applicable to burning plasmas in most other magnetic configurations.
- *Advancement of Fusion and Plasma Technology*: The achievement of burning plasma conditions will lead to advances in fusion and plasma technology essential to operation of a reactor and in basic materials science. However, a number of important technological and material issues facing a fusion reactor will remain to be addressed.
- *The Need for a New Experiment*: Present experiments cannot achieve the conditions necessary for a burning plasma. Therefore, addressing the important scientific issues in the burning plasma regime requires a new experimental facility.
- *Technical Readiness for a Burning Plasma Experiment*: The tokamak configuration is scientifically and technically ready for a high gain burning plasma experiment. No other magnetic configuration is sufficiently advanced at this time.
- *Range of Burning Plasma Options*: There exists a range of experimental approaches proposed to achieve burning plasma operation, from compact, high field, copper magnet devices to large super-conducting magnet devices. These vary widely in overall mission, schedule and cost.
- *Sufficient Information to Proceed to the Next Step*: Sufficient scientific information is now in hand to determine the most suitable burning plasma experiment for the U.S. program.
- *Cost of a Burning Plasma Experiment:* Approximate construction cost estimates of a burning plasma experiment range from hundreds of millions to several billion dollars. A burning plasma experiment, either a large scale international collaboration or smaller scale experiment solely within the U.S., will require substantial funding - likely costing the U.S. more than $100M per year.
- *Importance of the Base Program*: A healthy base science and technology program is needed to advance essential scientific and technology issues and to capitalize on advances made with the burning plasma experiment. Thus, a burning plasma experiment must be funded with a significant augmentation of the fusion budget.
- *Desirability of Multi-party International Experiment*: A multiparty international experiment has the potential of lowering the cost per party while retaining full technical benefits, representing a highly leveraged investment. However, the necessary political arrangements and multinational commitments can lead to delays and accumulated costs. In addition, the U.S. national scientific infrastructure benefits more from a burning plasma facility built in the U.S.
- *Desirability of Advanced Tokamak Capability*: Achieving burning plasma conditions does not require Advanced Tokamak (AT) capability. However, the AT line of research has the potential to significantly increase the economic attractiveness of the tokamak. Therefore, the AT capability is highly desirable.
- *Other Applications of Burning Plasmas*: In addition to fusion energy production, there are a number of other potential fusion applications compatible with reduced plasma performance (such as transmutation of nuclear

wastes and fusion-fission hybrid reactors) that would benefit from the knowledge gained in a burning plasma experiment.

- *U.S. Collaboration on JET*: The JET experiment has the capability to explore alpha particle physics, at low gain, in regimes relevant to burning plasmas. The U.S. would benefit from collaboration on this experiment.
- *Contributions to Other Fields of Science*: The conceptual basis and analytic/computational techniques developed in magnetic fusion research have been productively transferred to space-, astro-, accelerator-, and computational physics. The new regimes accessed in a burning plasma experiment (e.g. reconnection in the presence of energetic particles and fusion burn dynamics) will extend these contributions.

The draft version of the Panel's report also included the following recommendations:

1. Now is the time for the U.S. Fusion Energy Sciences Program to take the steps leading to the expeditious construction of a burning plasma experiment.
2. Funds for a burning plasma experiment should arise as an addition to the base Fusion Energy Sciences budget. (likely required to be on the order of $100M per year).
3. The U.S. Fusion Energy Sciences Program should establish a proactive U.S. plan on burning plasma experiments and should not assume a default position of waiting to see what the international community may or may not do regarding the construction of a burning plasma experiment. If the opportunity for international collaboration occurs, the U.S. should be ready to act and take advantage of it, but should not be dependent upon it. The U.S. should implement a plan as follows to proceed towards construction of a burning plasma experiment:
    - — Hold a "Snowmass" workshop in the summer of 2002 for the critical scientific and technological examination of proposed burning plasma experimental designs and to provide crucial community input and endorsement to the planning activities undertaken by FESAC.
    - — Carry out a uniform technical assessment led by the Next Step Options program of each of the burning plasma experimental options for input into the Snowmass summer study.
    - — Request the Director of the Office of Energy Sciences to charge FESAC with the mission of forming an "action" panel in Spring 2002 to select among the technically viable burning plasma experimental options. The selected option should be communicated to the Director of the Office of Science by January 2003.
    - — Initiate a review by a National Research Council panel in Spring 2002, with the goal of determining the desirability, as well as the scientific and technological credibility, of the burning plasma experiment design by Fall 2003. This is consistent with the submission of a report by DOE to Congress no later than July 2004.
    - — Initiate an outreach effort coordinated by FESAC (or an ad-hoc body) to establish an appreciation and support for a burning plasma experiment from science and energy policy makers, the broader scientific community, environmentalists and the general public.
4. The Next Step Options program should be expanded both financially and technically to include a technical assessment of ITER-FEAT, IGNITOR, and FIRE on a uniform basis.
5. Whereas two of the burning plasma experiments under consideration (ITER-FEAT and IGNITOR) are being pursued outside the U.S., we recommend that DOE engage the respective parties to facilitate the technical interaction needed for U.S. planning, begin informal discussions on possible U.S. involvement in those efforts, and establish the groundwork for productive collaborations among burning plasma efforts.

In response to a question, Freidberg agreed that, according to the Panel's proposed schedule, a US decision on a burning plasma experiment would occur after the European and Japanese decisions about ITER.

19. Public Comment on Burning Plasma Science Panel Report

David Baldwin (General Atomics):

A couple weeks ago he had sent to FESAC an email with an attachment describing his thoughts about a burning plasma experiment in a science program. Many of the same points were made in the University Fusion Association statement and the Burning Plasma Panel report. One theme he wanted to develop further is that there is too much focus on the capability of the machine to do science. What has not been addressed is the question of whether the science can be extracted. This will require diagnostics (and diagnostic access) and also run time. When the study that the Panel is recommending is done, this issue should be examined. Diagnostics is especially

important, due to the fusion environment (neutrons). ITER has done much diagnostic study, but this opportunity needs to be made available to the scientific community.

It is important to join as soon as possible as a negotiator in the ITER process. ITER does not exist right now. All parties are negotiating whether to join in construction. The US would also not be rejoining ITER, but would be joining negotiations and would later inform the other parties about whether it will join the construction. The US can make an informed decision about whether to do the latter only if we study capabilities and are involved in negotiations.

Bruno Coppi (Massachusetts Institute of Technology):

Marshall Rosenbluth's document "From Yearning to Burning" (UFA Burning Plasma Science Workshop, December 2000) should be read by everyone. It endorses the strong magnetic field approach.

Recently some MIT engineers (Schultz and Titus) published a paper on superconducting magnets, using IA/R as the primary parameter. With this as the criterion, strong magnetic field devices win hands down. IGNITOR came out with flying colors. Hence there has been progress in understanding.

He said that he disagrees with the Burning Plasma Panel report on two points, although he liked its presentation overall. The first point is: Why wait until the year 2004? It is possible to proceed faster than that. The second point is that the table that compares the physics parameters of the three concepts considered is wrong and should be corrected.

Rob Goldston (Princeton Plasma Physics Laboratory):

He discussed the Next Step Options process of preparing for Snowmass 2002. He said that it is critical that this be a success. It will be our opportunity to impress a distinguished National Academy of Science panel, which will decide whether we move forward with a burning plasma experiment. We need to prepare. We need working sessions to prepare, not workshops. For example, people could bring "experimental proposals" and run them on simulation codes, in order to examine what science can be done on the proposed machines. He announced that PPPL is offering to provide facilities to NSO/Snowmass for such working sessions. He suggests three 2-week sessions, held at the winter break, spring break, and summer. He listed further examples of working session topics: analysis of scientific capabilities of proposals; analysis of the benefits of each proposal to the portfolio; roll-forward analysis; roll-back analysis; analysis of impacts on other areas of science and technology. It is important to make a positive impression on the upcoming National Academy of Science panel at Snowmass.

He also announced the Sept. 12-14 workshop at PPPL that will celebrate the laboratory's fiftieth anniversary.

Thomas Jarboe (University of Washington):

He noted that two burning plasma workshops had been held recently, both sponsored by the University Fusion Association (which he chairs), the first led by Jerry Navratil and the second by Ron Parker. The University Fusion Association recently drafted a statement of technical policy on burning plasma. He read it in its entirety. (It is posted at http://depts.washington.edu/ufa/download_folder/bp_tech_policy.html.) He highlighted two sentences in this statement: (1) "The UFA supports the exploration of potential burning plasma experiments and advocates that this important next step be pursued by the US fusion energy sciences program. (2) "The UFA supports a balanced program for a faster realization of fusion power, requiring an increased base program as well as a burning plasma experiment."

20. Discussion of Burning Plasma Science Panel Report

The chair proposed the draft of a provisional statement to be sent from FESAC to OFES, concerning ITER Canada's request for US involvement. The chair explained the reasons for such a statement, viz., that it would be useful for the US to have a presence, and that this statement would directly respond to one of the Burning Plasma Science Panel's recommendations. FESAC discussed this statement. The chair decided to table further consideration of the statement until later in the meeting when FESAC would discuss its response to the Panel report.

Freidberg answered questions from FESAC members concerning the recommendations of the Panel.

McCarthy left the meeting at this point.

FESAC members discussed each recommendation of the Panel report in turn.

- Concerning Recommendation #1, there was discussion of the technical basis for a burning plasma experiment, the importance of doing such an experiment, and its relation to other program elements. In particular, Boozer expressed disagreement with the statement in the report that the knowledge gained from a burning plasma experiment based on a tokamak configuration must provide a firm basis for extrapolation, not only for the tokamak configuration but more generally across the broad family of toroidal magnetic concepts, and even to non-toroidal concepts.
- Concerning Recommendation #2, there was discussion about using some fraction of the existing base budget to help fund a burning plasma experiment, while still maintaining programmatic balance.

(Sauthoff left the meeting at this point.)

- Concerning Recommendation #3 of the Panel report, there was discussion about who would be responsible for appointing a high-level decision panel and whether the report allows for the option of the US building a burning plasma experiment on its own.
- Concerning Recommendation #4, there was discussion of how to evaluate and simulate various burning plasma options and prepare for the Snowmass 2002 meeting.
- Concerning Recommendation #5, there was discussion of its neutral language and whether a positive statement about ITER-FEAT should be included.

FESAC members were asked to submit written suggestions for modifying the text of the recommendations.

The chair presented a draft for a cover letter to the Office of Science concerning the Burning Plasma Panel's report. He noted that he had tried to write the letter so that it does not compete with the Panel's report, but simply states FESAC endorsement of the report. By unanimous vote, the FESAC approved the text of the proposed letter after some wording changes. (The text of this letter is given in Appendix C.)

FESAC continued to discuss the body of the Burning Plasma Panel's report. There was discussion of whether the report would be useful to communicate with the general outside scientific community and whether it sufficiently articulates the unique capabilities of a burning plasma experiment.

The chair returned to a consideration of the statement responding to ITER Canada's request for US involvement in the ITER process. He noted that Anne Davies has said that this statement would help her in moving toward some sort of re-engagement. In response to a comment, the chair suggested that some context be added at the front of this statement. He also noted that this statement would only be put on the record in the FESAC Minutes. By common consent, the FESAC then approved the following revised statement:

In the context of the Burning Plasma Science Panel recommendation #5 (viz., "The US needs to engage the international community in some appropriate capacity with respect to ITER-FEAT and IGNITOR so that these experiments, along with FIRE, can be evaluated on a level playing field."), FESAC recommends that OFES explore informal means for the US to participate in the ongoing ITER discussions.

21. Date of Next Meeting

The chair proposed scheduling the next FESAC meeting on December 11 and 12, 2001, in the Gaithersburg, MD, area. He noted that if there is not enough business on the agenda for that meeting, it might be postponed to a later date.

22. Adjourn

After again thanking PPPL for their hospitality, the chair adjourned the meeting at 4:15 p.m.

Minutes prepared by James W. Van Dam
FESAC Executive Secretary

Approved by:
Richard D. Hazeltine, FESAC Chair

APPENDIX A: Guest List

Name	August 1	August 2
David Anderson—U. Wisconsin	X	X
Dave Baldwin—GA	X	X
Herbert Berk—U. Texas		X
Peter Bernard—ITER Canada	X	X
David Conz—Arizona State U.	X	
Bruno Coppi—MIT	X	X
Dan Dautovich—ITER Canada	X	X
Steve Dean—FPA	X	X
Giorgio Einaudi—Pisa U.	X	X
Joe Fiordaliso—PPPL	X	
Chuck Finfgeld—DOE OFES		X
Harold Furth—PPPL	X	
Rob Goldston—PPPL	X	X
Michael Holland—OMB	X	
E. B. Hooper—LLNL	X	X
Thomas Jarboe—U. Washington	X	X
Steve Jardin—PPPL	X	X
Steve Knowlton—Auburn U.		X
Arnold Kritz—DOE OFES	X	X
Benoit LeBlanc—PPPL	X	
Grant Logan—HIF-VNL: LLNL/LBNL/PPPL	X	X
Jim Lyon—ORNL	X	X
Dale Meade—PPPL	X	X
Dobie O. McArthur—GA	X	X
Stan Milora—ORNL	X	X
Masayuki Nagami—JAERI	X	X
Hutch Neilson—PPPL	X	X
Al Opdenaker—DOE OFES	X	X
Ronald Parker—MIT	X	X
Jeff Quintenz—SNL	X	X
Gregory Rewoldt—PPPL		X
Michael Roberts—DOE OFES	X	X
Paul Rutherford—PPPL	X	X
Rick Savone—Government of Canada	X	X
John Schmidt—PPPL	X	X
Bob Simmons—PPPL	X	
Ronald Stambaugh—GA	X	X
Murray J. Stewart—ITER Canada	X	X
Ed Synakowski—PPPL	X	X
John Talmadge—U. Wisconsin	X	X
Nermin Uckan—ORNL		X
Harold Weitzner—NYU	X	X
Michael Zarnstorff—PPPL	X	X

APPENDIX B: FESAC Letter Endorsing Report of Theory Review Panel

Dr. James Decker, Acting Director
Office of Science
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Dr. Decker:

This letter responds to the charge received from Dr. Mildred Dresselhaus on November 9, 2000, to review the Office of Fusion Energy Sciences' program on theory and computation. FESAC formed a panel (chaired by Dr. John Sheffield–ORNL/UT and including FESAC and other community members) to provide findings and recommendations for our consideration. A copy of the panel's report is enclosed. The panel's "primary finding is that the quality, structure, balance and management of OFES Theory and computing Program are, on the whole, good." The panel has made several recommendations to improve the program. FESAC fully endorses the findings and recommendations of its Panel on the Theory and Computing Program.

Yours truly,

Richard D. Hazeltine, Chair
Fusion Energy Sciences Advisory Committee

APPENDIX C: FESAC Letter Endorsing Report of Burning Plasma Panel

Dr. James Decker, Acting Director
Office of Science
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Dr. Decker:

On October 5, 2001, Dr. Mildred Dresselhaus charged FESAC to address key questions pertaining to the prospects and value of a burning plasma physics experiment. The Panel formed to address these questions has issued it final report, which was reviewed by FESAC at its meeting on August 1, 2001. This report is enclosed.

FESAC fully endorses the recommendations of the Burning Plasma Panel. In particular, we agree with the Panel recommendation that a burning plasma experiment would bring enormous scientific and technical rewards. We also agree that present scientific understanding and technical expertise allow confidence that such an experiment, however challenging, would succeed.

Yours truly,

Richard D. Hazeltine, Chair
Fusion Energy Sciences Advisory Committee