December 5, 2000

Professor Mildred S. Dresselhaus, Director
Office of Energy Research
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Professor Dresselhaus:

As you know, the Fusion Energy Sciences Advisory Committee (FESAC) met in Bethesda, Maryland, on November 14 and 15. The meeting began with your remarks on fusion science as part of the Office of Science portfolio. We appreciated hearing your informed perspective on our changing program, and are grateful for your understanding of its challenges and goals. In addition, we heard two other presentations about new activities in the Office of Planning and Analysis; we began to address two charges from you concerning burning plasma physics and fusion theory; and we heard a presentation on the recent assessment of fusion science, performed by the National Research Council (NRC). Our discussion of the NRC assessment was lengthy and I think very useful.

The purpose of this letter is to respond to a third FESAC charge, which you outlined in your remarks and submitted formally in a letter (enclosed). I will organize our response by paraphrasing the letter.

1. Updating program priorities.
Are the priorities and thrust areas called out in the September 1999 Priorities and Balance report still valid? Are the strategic vision and five-year goals still valid?
We find that the priorities and thrust areas of the Priorities and Balance report are still valid and that its strategic vision regarding the next 5 years is still appropriate for the program.

The September 1999 FESAC document on Priorities and Balance (PB) has been well received by the fusion energy science community and by the Congress. This study was the result of an extensive multifaceted assessment, involving a large fraction of the community, through the Snowmass meeting and other venues. We find that the priorities and thrust areas of the PB report are still valid, and that the strategic vision regarding the next 5 years is still appropriate for the program. However, because budgets allocated by the Congress have fallen below the $300 million funding level on which FESAC based its 5-year goals, progress will be slower than anticipated. As pointed out in the PB report, lower funding levels will delay the planned assessment of confinement concepts in Magnetic Fusion Energy (MFE) due to reduced operating time on the major tokamak facilities and slower pace in development of exploratory concepts. Completion of the goals leading to a decision on major new facilities, such as an Integrated Research Experiment for Inertial Fusion Energy (IFE), are also likely to be delayed.

The charge that led to the PB report was focused primarily on the energy aspects of the program, within the context of a balance between MFE and IFE. Nevertheless, the FESAC response to the charge involved much discussion of the science priorities. The NRC report on the quality of science in the OFES

program, discussed in more detail below, reinforces and complements the PB report. Its recommendations will be very valuable in strengthening the program, especially in outreach to the broader scientific community. The continued commitment of the DOE Defense Programs to ignition on the National Ignition Facility (NIF) is a central element of the IFE strategy. FESAC has recommended that the IFE goals be re-examined when the effects of the Defense Programs rebaselining of NIF are better understood.

Does the Integrated Program Planning Activity (IPPA) report provide a guide for achieving the five-year vision?

The Integrated Program Planning Activity (IPPA) presents a framework and process to guide the achievement of the 5-year goals listed in the FESAC PB document—an achievement now slowed by budget limitations. In some cases, such as IFE, the IPPA identifies a detailed set of objectives and priorities in support of the 5-year objectives. In other cases the IPPA specifies a process to obtain the data needed for such detailed planning.

Certain features of the IPPA remain subject to revision by OFES; indeed the intent is to update the plan on a regular basis. The IPPA will be applied for the first time to the OFES program for FY02 activities. An assessment of the utility of the IPPA will be made following this initial application.

2. NRC Assessment of Fusion Science.
What is the FESAC reaction to the draft NRC report? Are the NRC findings consistent with the priorities of the program as seen by FESAC?
It is clear that the NRC conducted a thoughtful and penetrating study of the MFE scientific research program. We find the recommendations given in the NRC assessment to be compatible with FESAC's sense of the program priorities.

The FESAC heard a presentation from Dr. Robert Rosner regarding the assessment of fusion science conducted by the Fusion Science Assessment Committee of the NRC. We consider the NRC study to be of particular importance, and intend to respond to it in detail when the final version is available and we have had time to study it. The present comments regarding the report, based on Dr. Rosner's remarks and the draft copy that was shown to FESAC, should be regarded as a preliminary response.

It is clear that the NRC conducted a thoughtful and penetrating study of the MFE scientific research program. Its principal finding, that

the quality of science funded by the United States fusion research program in pursuit of a practical fusion power source (the fusion energy goal) is easily on a par with other leading areas of contemporary physical science

is noteworthy, and its reinforcement of the fusion community's recent emphasis on the scientific foundations of fusion is welcomed.

We find the recommendations given in the assessment to be compatible with FESAC's sense of the program priorities. We recognize in particular the importance of improving the ties between fusion science and other scientific research areas. The task of implementing the recommendations, such as the establishment of new Centers, will be a theme of future FESAC discussions. We also expect the recommendations to influence two recently established FESAC sub-panels, one studying burning plasma physics and the other reviewing the fusion science theory program.

In short the FESAC considers the assessment to be of a quality that deserves serious attention and respect. We are grateful to the NRC for its careful effort and we plan to respond positively to its recommendations.

3. Comparing the US fusion program to programs abroad.
Given the contraction of the program, are we still among the world leaders in fusion science?
Despite the different emphasis of its program and its smaller budget, the US remains among the leaders in certain key areas of fusion energy science.

The US fusion program is one of a number of fusion programs around the world; our budgetary contribution is roughly 16% of the total international investment. Consequently the US does not aim to be the undisputed leader in all technical areas. Rather, it strives to be among the leaders in selective areas, while working in a mutually supportive manner with other world programs.

It should be noted that the emphases of the various international programs differ. The US carries out a science program supporting the energy objective, while the European, Japanese and Russian programs, although scientifically strong, focus more directly on the energy mission. The European and the Japanese programs operate the two largest tokamaks in the world, with possible upgrades under discussion. Japan has recently brought into operation the world's largest stellarator, and a stellarator of comparable size is under construction in Germany. In contrast, the US has not invested in new major facilities on this scale in roughly two decades; indeed, budget constraints have even prevented significant upgrades of existing facilities. Meanwhile the Europeans, Japanese and Russians are completing the design of an integrated burning plasma experiment and have begun to explore the possibility of its construction.

Despite the different emphasis of its program and its smaller budget, the US remains among the leaders in certain key areas of fusion energy science. In MFE, the focus on science and innovation has allowed the US to play a leading role in theory and computing, and in exploiting the synergies between experiments and theory. The US is among the leaders in MFE experimental research, with strong scientific emphasis on such topics as macroscopic stability, transport and advanced tokamak physics. The US supports an exceptionally broad program in innovative confinement research, although the largest non-tokamak devices are found in other countries. The US is also a leader in materials research, advanced design studies, safety research and innovative fusion technologies.

Because of the large DOE Defense Programs (DP) investment, the US has clear international leadership in the science of Inertial Confinement Fusion. This DP investment has given the US the opportunity to explore the possibility of the inertial confinement approach to fusion energy for a relatively modest increase in investment in fusion energy science. Integration of IFE into the US Fusion Energy Science Program was a major result of the FESAC Priorities and Balance recommendations. Increased co-ordination of the Inertial Confinement Fusion program conducted by DP and the IFE research conducted by OFES, as recommended by SEAB, is desirable.

The US position in international fusion science can be attributed to previous investment in advanced computing, innovative diagnostics, and enabling technologies, such as plasma control. In addition, an effective international collaboration infrastructure has allowed US scientists and engineers to keep up with developments abroad, and to work closely with our international partners through coordinated experiments on multiple facilities. The US participation in

joint, leading-edge activities with other nations is evidence of the strength of the US program, since the collaborations must be deemed mutually beneficial.

Nonetheless, the US position in MFE is being eroded. Fusion programs abroad, even if focused on energy, have strong science components whose quality and value compete with those of the US program. They also have facilities that enable science studies at scales inaccessible here. The European and Japanese programs are moving towards leadership in research involving long-pulse and high-auxiliary heating power, and they have much larger facilities for exploring innovative confinement strategies. In the critical area of long-pulse confinement, South Korea is now constructing a superconducting tokamak nearly identical to one proposed several years ago in the US and deemed desirable but too expensive.

Are we capable of responding quickly to breakthroughs in fusion research abroad? The US may be losing its capability to rapidly respond to breakthroughs in fusion research abroad, because of contraction of the MFE program and limited participation in programs on the leading facilities worldwide. This is especially true if the response requires modification of existing facilities or development of new technologies.

In experimental research, the US program can respond to foreign breakthroughs only if it maintains a critical investment in the development of diagnostic and plasma control tools, aimed at critical-path and hitherto unexplored areas. An example is the study of electron energy transport, which requires the probing of turbulence with an order of magnitude smaller spatial scale. Increased use of existing facilities, coupled with upgraded diagnostic, heating and current-drive capabilities, will be required.

In theory and computing, an opportunity exists for the program to make significant progress in fundamental understanding and predictive modeling capability of fusion energy confinement systems, through a strong partnership with the Advanced Computing Initiative of the Office of Science. Doing so will enable the US to maintain a leadership position in some key areas and to continue its mutually beneficial collaborations with other world programs.

We wish to thank you again for your participation in the FESAC meeting, and for your help and advice to the fusion science community.

Yours truly,

Richard Hazeltine
Chair, Fusion Energy Sciences Advisory Committee

RDH/cv

Enclosure

cc: N. A. Davies
FESAC