May 3, 2001

Dear Colleague:

The Next Step Options activity has focused on developing the pre-conceptual design for a burning plasma experiment capable of attaining burning plasma conditions (Q >5) for a burn time of ~ 20 seconds with a project cost ~$1B. These general considerations have led to an engineering design concept based on a high field compact tokamak with cryogenic copper alloy coils. The present design concept called FIRE (Fusion Ignition Research Experiment) incorporates physics and engineering advances made during the 10 years since the CIT and BPX design activities were completed. In several areas we have been able to take advantage of design work and R&D done for the ITER project. The National FIRE activity has developed a pre-conceptual design of all key engineering subsystems, identified key R&D items and has completed a rough cost estimate. The Engineering Status report for FY 2000 can found on the web at **http://fire.pppl.gov** or is available on request.

The overall purpose of an External Review of FIRE is to have an independent technical review of the major subsystems that are critical to the success of the mission, assess the adequacy of the present approach, identify areas of concern and to offer suggestions for modifications. Due to limitations of time and resources, we plan a External Review meeting scheduled for June 5-7, 2001 at Princeton Plasma Physics Lab that will concentrate on magnets, structures, vacuum vessel, plasma -facing components, internal remote maintenance (IRM), fueling and pumping. Other subsystems such as Tritium, Neutronics and Activation, and Facilities will be done individually by mail/conference call this fiscal year, while remote handling, and ICRF heating will be done next fiscal year.

The External Review Committee includes Charles Bushnell (Chair), Saurin Majumdar (Argonne), Fred Puhn (GA), Jim Irby (MIT), Peter Mioduszewski (ORNL), Ron Parker (MIT), Aldo Pizzuto (Frascati) for the meeting at PPPL. The individual system reviewers are Scott Wilms (LANL-Tritium), Yousry Gohar (ANL-Neutronics and Activation) and John Commander (INEEL-Facilities). The agenda for the June 5-7 External Review meeting is included as Attachment #1. More specific charge questions are included in Attachment #2.

I thank you for your willingness to serve on this External Review of FIRE, and I look forward to receiving your advice.

Regards,

Charles C. Baker
Deputy Director, Center for Energy Research
Director, Virtual Laboratory for Technology
Adjunct Professor, University of California/San Diego
9500 Gilman Drive, MC 0420
La Jolla, CA 92093-0420, USA

Review of FIRE TF, PF, Structures,VV, PFC's, IRM, Fueling and Pumping
Princeton Plasma Physics Laboratory-Room TBD
June 5-7, 2001

Note: (XX+YY)=(minutes for presentation+minutes for clarification questions)

Tuesday, June 5—TF/PF/Structures		
Organization of Review and Charge to Reviewers	Schmidt & Chairman of Reviewers	0830-0900
Physics Objectives and FIRE Design Point	Meade (30+15)	0900-0945
Design Point Trade Studies --Impact of Margin on Cost	Schultz(30+15)	0945-1030
Break		1030-1045
Machine Configuration	Brown (20+10)	1045-1115
Discussion of Presentations		1115-1145
Nuclear Effects and Activation	Sawan (20+10)	1145-1215
Lunch		1215-1315
Design Criteria & Allowables	Zatz (20+10)	1315-1345
Structural Analyses	Titus (60+15)	1345-1500
Break		1500-1515
Discussion of Presentations		1515-1545
Cost Estimating Methodology & Cost Summary	Simmons (20+10)	1545-1615
TF/PF/Structures Cost Estimates and R&D Needs	Heitzenroeder (30+15)	1615-1700
Discussion and Chit Preparation		1700-1800
Wednesday, June 6----VV, PFC's, Internal Remote Maintenance (IRM) , Fueling and Pumping		
Review Committee Meeting	Chairman	0800-0900
Vacuum Vessel including internal remote maint (IRM)	Nelson (40+20)	0900-1000
Break		1000-1015
VV Cost Estimates and R&D Needs	Nelson (20+10)	1015-1045
Discussion of Presentations		1045-1115
Divertor and Structures including IRM	Dreimeyer (45+15)	1115-1215
Lunch		1215-1315
Plasma Facing Components	Ulrickson (45+15)	1315-1415
Divertor & PFC's Cost Estimates and R&D Needs	Ulrickson & Dreimeyer (20+10)	1415-1445
Discussion of Presentations		1445-1515
Break		1515-1530
Fueling and Pumping Design	Gouge (20+10)	1530-1600
F&P Cost Estimates and R&D Needs	Gouge (20+10)	1600-1630
Discussion and Chit Preparation	All	1630-1800
Thursday, June 7---Reviewers Comments and Report		
Review Committee Meeting	Chairman	0800-0900
Questions of Clarification to Team	Chairman	0900-1000
Preparation of Draft Reviewers Report	Chairman	1000-1400
Report Summary to Team	Chairman	1400-1430
Discussion	Chairman	1430-1530

Attachment #2 Draft Charge to the Next Step Options Engineering External Review Committee

June 5-7, 2001 at PPPL

June 5 Magnet Systems

1. **Adequacy of the FIRE Magnet Engineering Designs to Meet Mission Requirements**

   a. Are the engineering design choices that have been made appropriate for FIRE's mission and cost goals?

   b. Are the proposed structural design criteria appropriate?

   c. Are the structural and thermal margins of the baseline magnet systems adequate? Are some of the margins too conservative?

   d. Are the proposed materials choices appropriate from both the structural, neutron damage, and manufacturing points of view? Are there better materials?

2. **Adequacy of the magnet R&D plans and costing methodology to meet the FIRE design requirements**

   a. Is the proposed R&D adequate? If not what items should be added?

   b. Is the methodology used to develop cost estimates appropriate? Are there concerns about the magnet cost estimates?

3. **Choice between Bucked and Bucked and Wedged TF System Designs**

   a. Considering performance, manufacturability, and risk tradeoffs between the baseline wedged TF magnet systems and the bucked and wedged variant:

   b.

      1. Does the appraisal of these factors by the FIRE project appear to be reasonable?

      2. Is the choice of system design that FIRE made the most appropriate?

June 6 Vacuum System, PFCs, IRH, Fueling and Pumping

4. Adequacy of the Vacuum Vessel, PFCs, IRH and Fueling and Pumping Systems

a. Is the design, fabrication, and assembly approach for the vacuum vessel appropriate? Are the RH plans adequate for servicing in-vessel components?

b. Has the vacuum vessel been adequately analyzed for this stage of the design, and does it have adequate design margins for both normal and disruption conditions?

c. Does the vacuum vessel have an adequate number and size of ports for diagnostics and maintenance?

d. Are the proposed VV R&D plans adequate?

e. Is the vessel costing methodology reasonable?

f. Is the choice of first wall materials appropriate?

g. Have the PFCs been adequately analyzed and do they have adequate:

1. design margins for electromagnetic loads resulting from normal operation and plasma disruptions.?

2. Erosion lifetimes.

h. Are the planned PFC design concepts flexible enough to accommodate design and material changes that operational experience may bring?

i. Are the planned PFC maintenance methods reasonable ?

j. Are the PFC R&D plans adequate?

k. Is the methodology used to develop the PFC cost estimates reasonable?

l. Is the type, number and location of fueling injection locations adequate?

m. Does the vacuum pumping system have adequate performance and operational characteristics to support FIRE's planned operation?