



**FUSION ENERGY SCIENCES ADVISORY COMMITTEE
OFFICE OF SCIENCE**

Hilton Gaithersburg, 620 Perry Parkway
Gaithersburg, MD 20877
Thursday, January 31, 2013 at 9:00 am.

Agenda Thursday, January 31, 2013

Time	Topic	Page	Speaker
9:00	Welcome, Meeting Agenda and Logistic		Dr. Martin Greenwald, FESAC Chair, Massachusetts Institute of Technology
9:05	FES Perspective		Dr. Ed Synakowski, Associate Director for Fusion Energy Sciences
10:15	Break		
10:45	Briefing from the Subcommittee on Magnetic Fusion Energy Program Priorities		Dr. Robert Rosner, Subcommittee Chair, University of Chicago
12:00	Lunch		
1:00	Presentation on the EU Pathway/DEMO studies		Dr. Francesco Romanelli, Leader, European Fusion Development Agreement, Associate Leader, Joint European Torus
1:30	Plans for Dealing with the New charge on Scientific Facilities Prioritization		Dr. John Sarff, Chair of the Subcommittee on Scientific Facilities Prioritization, University of Wisconsin, Madison
2:30	Break		
2:45	Public Comment		TBD
3:15	Discussion of the Report from the Subcommittee on MFE Program Priorities		Dr. Martin Greenwald, FESAC Chair, and FESAC Members
	Preparation of the Letter to DOE Concerning Completion of the Charge on MFE Program Priorities		
5:00	Adjourn		

Dr. Martin J. Greenwald, Chairman, was presiding.

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WELCOME

Dr. Greenwald thanked committee members for attending especially in view of bad weather conditions. He advised members of the audience interested in making public comments to see Albert Opdenaker who would organize accordingly. He made announcements regarding luncheon arrangements that had been made at the hotel restaurant for committee members. He noted that this would assist members in adhering to the agenda in which only an hour had been allotted for lunch.

ROLL CALL

Committee/Voting Members Present:

Dr. Martin J. Greenwald, Chair (MIT)
Dr. Richard W. Callis (General Atomics)
Dr. Bruce Cohen (LLNL)
Dr. Raymond J. Fonck (Univ. of Wisconsin)
Dr. Amanda Hubbard (MIT)
Dr. Hantao Ji (PPPL)
Dr. Christopher J. Keane (LLNL)
Dr. Ramon Leeper (SNL)
Dr. Kathryn McCarthy (INL)
Dr. Dale M. Meade (FIRE, LLC)
Dr. Ellen Meeks (Reaction Design)
Dr. Farrokh Najmabadi (UC San Diego) – (Part-time attendance)
Dr. Robert Rosner (Univ. of Chicago) – (Via Skype from Beijing)
Prof. Edward Thomas, Jr. (Auburn Univ.)
Dr. Nermin Uckan (ORNL)
Dr. Steven Zinkle (ORNL)

Ex officio Members Present:

Dr. Fred Skiff (Univ. of Iowa)
Dr. Minami Yoda (GIT)

DOE Attendees:

Sam Barish (FES)
Curt Bolton (FES)
Ben Brown (SC)
Alicia Chambers (FES-Temp)
Steve Eckstrand (FES)
Sean Finnegan (FES)
John Glowienka (FES)
Randall Laviolette (ASCR)
John Mandrekas (FES)
Gene Nardella (FES)

Committee/Voting Members Absent:

Dr. Riccardo Betti, Vice-Chair (U. of Rochester)

Ex officio Members Absent:

Dr. John W. Steadman (IEEE)

Other Attendees:

David Gates (PPPL)
Charles Greenfield (GA)
Julie Groeninger (Princeton Univ.)
Mark Haynes (Concordia Power)
Donald Hillis (ORNL)
Stephen Knowlton (Auburn Unvi.)
Jon Menard (PPPL)
Stan Milora (ORNL)
Hutch Neilson (PPPL)
Martin Peng (ORNL)

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Erol Oktay (FES, Retired)

Albert Opdenaker (FES)

Nirmol Podder (FES)

Ann Satsangi (FES)

Edward Stevens (FES)

Barry Sullivan (FES)

Dr. Ed Synakowski, Associate Director, FES

James Van Dam (FES)

Tom Vanek (FES)

Miklos Porkolab (MIT)

Juergen Rapp (ORNL)

Don Rej (LANL)

Francesco Romanelli (EFDA)

John Sarff (Univ. of Wisconsin)

Tony Taylor (GA)

Anne White (MIT)

Michael Zarnstorff (PPPL)

FES PERSPECTIVES

Dr. Ed Synakowski, Associate Director of the Office of Science, for Fusion Energy Sciences

- Thanked committee members and audience for attending the meeting.
- Took the opportunity to thank members for their ongoing efforts and noted that they would be hearing from Dr. Robert Rosner regarding the charge issued by Dr. W.F. Brinkman in April 2012.
- Welcomed many audience members and Dr. Francesco Romanelli who would present on the roadmapping activity for their program in the EU (European Union).
- Stated that he would be providing updates on Fusion Energy Sciences (FES):
 - He discussed the new FES organization chart and stated that the office had been reorganized to align it with the Office of Science where it typically has a research division and a facilities and operations division. He noted that for FES the Facilities Division was now called the Facilities, Operations and Projects Division.
 - He noted that FES is in the process of hiring a director for the Facilities, Operations and Projects Division. He said that they were reviewing an outstanding group of candidates.
- Referred to the FES FY 2013 budget situation and commented as follows:
 - It is being handled in a manner consistent with the other offices in SC.
 - He remarked on the extraordinary budgetary times and the fact that the SC had not received closure on the FY 2013 has not yet been reached
 - He stated that FES and the other offices in SC are operating conservatively given they are still dealing with a Continuing Resolution (CR).
 - All of the SC programs have been given 47% of the CR funding for the first six months of FY 2013.
 - He explained that the algorithm applied is that the CR funding is equal to the lowest of the FY 2012 appropriated budget or the administration's FY 2013 budget request, or the House mark or the Senate mark. He noted again it is a conservative approach and that different parts of the program are operating to give them the maximum possible margin.
 - The FES was allocating funds to try to avoid an irreversible impact on the program.
 - He commented that the Department is in the middle of negotiations for the FY 2014 budget request and the pass-back from OMB has just recently been received which is about two months later than it would have been received in a "normal" year. How this will affect the timeline for the rest of the budget process is not yet known.
 - He referred members to the list of solicitations in play for FY 2013 in the set of slides that he had handed out and he noted that a large number are on hold to maintain the maximum amount of

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budget flexibility. He said that in many cases there had been no-cost extensions issued to existing proposals to enable the work to continue.

- With regard to FESAC (Fusion Energy Sciences Advisory Committee) membership he stated that:
 - All of the current FESAC members had their membership terms extended until February 20, 2013 to allow them to complete the action on the MFE Priorities charge that will be dealt with later that day.
 - Since that extension had been granted, a new charge has been given to FESAC to deal with Prioritization of scientific user facilities for 2014-2024 and that charge is due to be completed by March 22, 2013. This has required that FES request yet another extension of FESAC membership terms until June 3, 2013 to allow time for the completion of that charge with the current committee intact.
 - He noted that this new charge would require that another FESAC meeting be held before the March 22, 2013 due date for that charge, and it may be necessary to have an additional meeting to deal with the FY 2014 President's budget depending on when that budget is made public. He said that all SC offices are dealing with limited travel budgets and he said that FES is were considering having at least one of these additional FESAC meeting be held in the format of a webinar. He added that it had been done previously and commented that Advanced Scientific Computing Research Advisory Committee had done this during Hurricane Sandy.
- Discussed FESAC activity to assess MFE (Magnetic Fusion Energy) priorities that would be dealt with later in this meeting:
 - The charge was issued in April of 2012, at the beginning of a period of extreme budget-induced community stress.
 - He added it was not surprising given the size of the community and how passionate it was that there would be challenges in confronting the charge.
 - He acknowledged the effort in managing the charge under difficult circumstances was vigorous and he looked forward to hearing the results.
 - He thought that some of the issues that emerged in the execution of the charge will have a lasting effect on how future subcommittee activities would be carried out.
 - He thanked all the members of the FESAC subcommittee chaired by Dr. Rosner.
- Discussed the new FESAC charge on Science User Facilities Prioritization:
 - He said it was an Office of Science-wide activity that was issued by Dr. Brinkman and it was intended to identify facility investments across SC that should be made in order to ensure and promote U.S. leadership in the world especially considering the investments currently being made globally.
 - The DOE (Department of Energy) established a goal for the Office of Science. The goal is: "Prioritization of scientific facilities to ensure optimal benefit from Federal investments. By September 30, 2013, formulate a 10-year prioritization of scientific facilities across the Office of Science based on (1) the ability of the facility to contribute to world-leading science, (2) the readiness of the facility for construction, and (3) an estimated construction and operations cost of the facility."
 - He added that it was not only a facility but also upgrades to existing facilities.
 - With reference to the stated goal the SC requested the federal advisory committees for all six program offices to identify and characterize high priority new facilities and upgrades according to two criteria: "The ability of the facility to contribute to world-leading science in the next decade (2014-2024) (a) absolutely central; (b) important; (c) lower priority; and (d) don't know enough yet." The second was: "The readiness of the facility for construction (a) ready to initiate

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- construction; (b) significant scientific/engineering challenges to resolve before initiating construction; and (c) mission and technical requirements not yet fully defined.”
- He indicated that the time schedule was compressed and the final report is needed by the DOE by March 22, 2013. He said that Dr. John Sarff and Dr. Don Rej had graciously agreed to be the Chair and Vice-Chair of this subcommittee.
 - He commented that with regard to the charge the DOE General Counsel had advised members that they would have to adhere to DOE practices for non-FACA (Federal Advisory Committee Act) panels with regard to COI (Conflict of Interest). He outlined the Department’s practices with regard to circumstances when members could and could not participate in discussions and the circumstances under which they might have to recuse themselves. The rules would apply to members if they were or were not members of the parent FACA committee. It was also noted that if a member recused him or herself the subcommittee would not consider any information pertaining to that facility presented by such a member as they would be viewed as having a bias because of that employment relationship. Members who recused themselves from such discussions should leave the room during these discussions.
 - With respect to the guidance received from DOE General Counsel, he added that the standard should be: what would a reasonable person do to eliminate any bias they may be seen to have when dealing with the issues being discussed.. He noted his understanding was that what the General Counsel was doing was providing guidance for the members of subcommittees to follow because the General Counsel wants to help the subcommittees maintain the highest possible level of integrity when carrying out its role. He stated that it would depend on people articulating what the practice is and describing the process with oversight including working with the designated federal official and working collaboratively to ensure that correct practices are followed. He commented that in the end one would have to determine if it was reasonable, would a reasonable person find a problem or not with respect to how the conclusions were developed, how the discussion took place and how any conflicts of interest might have influenced the end result. He remarked that with respect to the Rosner report they made a good-faith effort to respond to the issue of a heightened level of awareness of any conflict of interest.
 - Discussed the process of how members would proceed with the charge:
 - The FES would provide a list of proposed new facilities and upgrades.
 - The list would be made available to Dr. Martin Greenwald, Dr. John Sarff and Dr. Don Rej.
 - The FES had developed a small list of proposed items for consideration by the committee. The FES had already developed its own assessment. He confirmed that the activity would not just be to evaluate the list but it was to be a starting point for the committee and the subpanel to work with the community and have advocates come in and make their case. He indicated they were free to change the importance of what had been put forward or to reject any facility.
 - He explained that the subcommittee should consider that what FES had put forward was a vehicle for conveying what FES thinks is important scientifically that that it could be considered a seed for the subcommittee’s discussion. He said the committee should weigh in and provide their opinions and the advocates should also present their ideas.
 - He confirmed that the list was not a prioritized list.
 - He asked that the list that the subcommittee would generate not have an explicit or implied priority.
 - He indicated that the number of proposals on the list that FES sent to the subcommittee was kept small recognizing that there are six offices in the SC.

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- Discussed FES guidance to the FESAC community regarding input:
 - FESAC may add or subtract from the FES proposals but the final FESAC recommendations should be realistic and focused.
 - ITER is not to be considered due to its international character and agreements
 - NSTX-Upgrade was not to be considered as it is well underway
 - In the charge there is a lower boundary of facility costs of \$100 million but it should not be considered a decisive boundary. FES had been encouraged to tell subcommittee members to consider a physicist's view of \$100 million or about a factor of 2.
 - He said they had an opportunity to package coherent bundles of upgrades or of smaller facilities when considering the lower boundary
- Discussed the FES proposed list:
 - An upgrade package for the DIII-D National Fusion Facility Upgrade. It was rated as important under contributions to world-leading science. They had stated that the upgrade package would provide access to new physics regimes allowing investigations and detailed those areas. It was rated as ready to initiate construction and indicated that conceptual designs had been developed with no technical barriers identified for the upgrades and the results of such construction were listed. He indicated that he would not be making a case but noted that FES considered it important. He said it was an example of a bundled set of upgrades for an existing facility. He said they could also consider new facilities that would be aligned along a physics theme that would lead to world-leading capability.
 - A Materials Facilities Initiative which had been rated as absolutely central. He indicated that the initiative would provide two cost-effective test facilities that could replicate extreme fusion conditions for the first time, providing information for the design of FNSF (Fusion Nuclear Science Facility) and allowing investigations of the behavior of materials under irradiation by 14 MeV neutrons and irradiation by combined high heat and particle fluxes. Under readiness for construction it had been rated as ready to initiate construction but some power source R&D (Research and Development) would be required. He indicated that they wanted to construct a modification to the spallation source at Oak Ridge National Laboratory (ORNL).
 - He noted that the Fusion Nuclear Science Facility was different. He asked the committee members to do a diligent job with respect to smaller scale upgrades. He noted that the opportunity was to identify the classes of facilities that fusion and U.S. fusion would need. He asked members to give attention to the smaller scale projects given the budget realities as it might be an important input for Dr. Brinkman. He stated that the U.S. perspective generally is that it is rated as absolutely central. He stated that the FNSF would provide the first-ever fully integrated fusion nuclear environment uniquely suited to investigate and understand: fusion plasma-material interactions; radiation effects on materials; tritium fuel sustainability; power extraction; and full remote handling operations. He stated that with regard to readiness for construction there were significant scientific/engineering challenges to resolve before initiating construction and some of these were: optimum magnetic configuration; auxiliary heating and current drive systems; operating scenarios and control systems; and structural material and plasma-material interaction data from Materials Test Facilities. He stated that they recognized these were large, open questions and they encouraged the committee to use the activity as an opportunity to define those questions and then choose whether to recommend and to put it forward.
 - He referred to the last item on the list, Quasi-Axisymmetric Stellarator Research (QUASAR) Experiment. He noted that the interest in stellarator physics is keen and expertise is strong

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within the U.S. He stated that the stellarator community has different views on what the best next step would be. He said the project represented by QUASAR was a new name for an endeavor to complete the assembly of a stellarator that had been the NCSX experiment. He said that they did not have a technical judgment on the best path forward but from an FES perspective on what is known about budgets anything of this scale that would be proposed that is not this would be considerably more expensive. He thought that this reflects their own understanding of what the budget realities are likely to be. He said that it builds on a strong national view that this is an important experiment to do. This would be the world's first stellarator designed on the basis of quasi-axisymmetry, allowing investigations of: operating limits; neoclassical and turbulent transport reduction; passive control of islands and instabilities; and power and particle exhaust. It was noted as ready to initiate construction with the statement that some components (3D coils, vacuum vessel, and toroidal field coils) have already been fabricated and assembly has been demonstrated. He noted he wanted to know if the committee had a view on the risks regarding construction and if those risks have been retired or are likely to be reasonably retired. He suggested that there might be an interesting dialogue here that could occur with the subpanel with community advocates who would talk about the scientific wisdom on going in another direction regarding stellarator physics using more readily-constructed designs. He stated that they would need to weigh that against cost issues in starting anew as opposed to continuing with an existing project.

- Confirmed that the last step would be that the subcommittee would complete the un-prioritized list and then FESAC would then formally put it forward to Dr. Brinkman at the end of March 2013. Dr. Brinkman would then finalize the list. He said that he was not aware of what the nature of any internal discussions would be but he noted that Dr. Brinkman viewed the activity as personally important in terms of status and what it would mean for the future of U.S. leading facilities and their potential impact in the long run. He stated there was some similarity with the exercise they were about to embark on with the publication put out in 2003 called *Facilities for the Future of Science: A Twenty-Year Outlook*. He added that most of the top ten on that list had had significant progress forward or were in the process of construction.

COMMITTEE DISCUSSION

Dr. Greenwald noted that it was open for discussion. He began the discussion with the issue of conflict of interest as it had bearing on the operation of FESAC. He considered that this was a matter of practice as opposed to law and he thought that there was an opportunity for dialogue within the department and he recommended that Dr. Synakowski discuss that with other ADs. He thought that the definition provided might not be appropriate in a scientific setting and was perhaps narrow. He thought it had to do with financial interests of specific institutions. He stated that there were many kinds of biases that could be positive or negative in a zero sum-budget. He added that there were emotional biases where people sitting on committees had been part of a decision-making process for decisions that were now being reviewed. He added there were also cognitive biases. He thought that it would assist the offices if there was a dialogue to discuss these issues and come to some agreement where they were not put into a position where they had so restricted the technical input into the subpanel processes that there would be no one on them with sufficient technical expertise because many with that technical expertise would have potential conflicts. He noted that he was concerned that having too many technical constraints would result in the advisory committees not delivering the best advice.

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Dr. Synakowski responded that he agreed there were multiple potential sources of conflict. He acknowledged that counsel might not have mentioned them but the SC was cognizant of them. Dr. Greenwald acknowledged that but stated that he did not want to have too broad a definition of conflict and then exclude anyone with any appearance of conflict resulting in a lack of technical expertise. Dr. Synakowski stated he was right in that the panels have to have technically-competent people and he thought even though the community was small they would have the flexibility to manage it properly. He noted that they would probably learn as more of the same type of panel activity was conducted in the future and so they would pay close attention to how it was working and get feedback from the advisory committees. He said it would always come down to the question of what would a reasonable person judge in any aspect of conflict of interest and it would ultimately be up to the judgment in the federal offices to gauge whether a reasonable approach had been applied.

Dr. Raymond Fonck referred to the 2003 report and the subsequent update and noted it was based on a 20-year horizon. He said that the current discussion relating to Dr. Brinkman's charge was 10 years and said that it was a "10 year ready to produce science or before that". He asked if he anticipated the report coming out of the Office of Science being another 20-year horizon. Dr. Synakowski responded that it should be what the charge reflected so 10 years. Dr. Fonck referred to the conflict of interest issue and said there were a few facilities that existed and if they were to be discussed the conflict would be clear. He continued that the subpanel was supposed to be considering the future and he noted that FES would want to have a situation where that panel would say we need this or that capability. But he said there were no stated choices as to where it would go or who would do it. He thought that that would be opened up to competition so he thought in that sense the conflict of interest would not seem as restrictive as suggested. Dr. Synakowski agreed with him and gave an example of the DIII-D package. Dr. Fonck added that that should be the guideline so people with technical input and advocates in the discussion would not necessarily be the same people who would do it.

Dr. Bruce Cohen referred again to the conflict of interest issue. He noted that he was on the Rosner panel and after Dr. Synakowski had met with the panel they had become very aware and careful with regard to conflict of interest issues. He added that when discussions took place concerning specific facilities the room was cleared of all people who would have had a conflict. He gave an example of how his affiliation with a certain facility might require him to remove himself from discussions on both the committee and subpanel and wondered if they were overdoing their consideration of issues of conflict of interest.

Dr. Cohen referred to the new charge and said he assumed that they were going through the process outlined in the charge as a result of funding shortfalls and that in 10 years there would be some energy to consider new facilities. He stated that it was his opinion that it was important for the field of fusion to have new facilities in order to produce leading science but it was more important to have the people to do that leading science. He referred to the Rosner Report and noted that one of its findings was that they questioned whether the FY 2013 budget, in view of the amount of funding being allocated to ITER, would maintain the necessary workforce and attract new scientists to allow FES to do leading science. He said why put more strain on the existing budget by building new facilities at the expense of existing facilities where reduced budgets meant turning away talented scientists from the field. Dr. Synakowski responded that he would recommend not overthinking the constraints. He noted that the presence of ITER would yield a strong recommendation that they need to consider the smaller-sized budget items.

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He stated that they had learned a lesson in the financially successful programs and that was to be prepared and the importance of optimistic thinking.

Dr. Dale Meade referred again to the issue of conflict of interest and noted that there was the legalistic approach and the other conflicts such as financial or emotional etc. He thought that they should construct a panel that would have a balance of conflicts, not just affiliation with institution but a total balance. He thought that having that type of spectrum on a panel was important. He added that conflicts could also be addressed by having an increased transparency on the panel's activities and perhaps less closed-door meetings which could be productive but were not so open. He noted that an increased transparency where there was an increased opportunity for feedback would also be an improvement. He suggested there could be more open documentation such as posting position papers of panel members or topics under discussion on a panel website which would also keep the process transparent. He noted that having more frequent meetings of the advisory committees would also lead to more open discussion, such as the reporting of preliminary findings with feedback would be an additional way of reducing conflicts of interest.

Dr. Synakowski responded that in observing the Rosner panel he considered it open including how it had solicited input. He indicated that there was another model which was a panel, clearly un-conflicted but comprised of very senior people who would have deep experience in scientific governance, perhaps at the national laboratory level. He said one would hope to find people who were un-conflicted and would have technical expertise. He said there are such models used within the administration where that type of panel is assembled and then advocates come and make their technically-informed case and then an assessment would be done. He indicated that it had been suggested that this was something they might follow in the future. He added that they had no present intention to do that but it was an option to consider. Dr. Synakowski referred to the issue of conflicts of interest again and noted that with regard to Dr. Meade's comments, his understanding of what the National Academy did was to go through a process of everyone openly declaring their conflicts and it could become a time-consuming process. He said that option was discussed in the context of SC advisory committees and guidance was given that that was not what was to be done.

Dr. Meade referred to facilities and agreed with Dr. Cohen that when talking about major facilities one might be talking about a longer period than 10 years. He said they hoped that the facilities panel could have some way to have a longer view than something that would yield major, ground-breaking experimental results within 10 years. Dr. Synakowski responded that the standard might be whether it yields ground-breaking in 10 years, certainly not completion. Dr. Meade made a reference to 'blue sky' and the real world and asked about the minimum level of \$100 million for the facilities considering the FES was dealing with a tight budget. He stated that he was glad that major elements were being considered. He asked if the facilities panel would be working with cost estimates of the initiatives. Dr. Synakowski responded to the degree possible. Dr. Meade referred to the FNSF and asked if it could be broadened to be a program or multiple facilities. Dr. Synakowski responded that he had discussed the idea of a program with Dr. Brinkman and they determined that that would not go forward. Dr. Meade asked if the term project meant more than one facility. Dr. Synakowski responded that that was a decision they would have to make at the appropriate time. Dr. Meade noted that the panel should have a clear understanding of the FES vision and program goals if they were going to be assessing the priorities. He thought that a statement from the office to the panel might be helpful.

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Dr. Christopher Keane referred about the size of facilities. He referred to the smaller facilities and said they had stated that less than \$100 million might be considered. He asked if the focus was on major facilities or if they would consider a single smaller facility that was well under \$100 million. Dr. Synakowski responded that it was a judgment call. He said that single facilities less than \$100 million would be in the scope of the study.

Dr. Amanda Hubbard referred to his comments about the uncertainty of the position for the FY 2014 budget. She asked if input or recommendations from FESAC would have the potential to influence those budget decisions. Dr. Synakowski responded that the discussion is ongoing and he would welcome the committee's input. She referred to previous discussions regarding the FES strategic plan in 2009 when they were to discuss an overall strategic plan but could not do so. She stated it appeared to be an issue that had not been addressed. She wondered about the current status and asked if the SC had a plan for FES. Dr. Synakowski responded that the SC had communicated to the Hill the fact that they had not been able to formulate a strategic plan by the December 2012 goal due to the ambiguity of the budget situation. He said that some questions had to be clarified on what was the administration's view on the direction of science of this class.

Dr. Hubbard referred to the U.S. cost for ITER. She raised some questions about the total cost of ITER and when that would be known as the last communication she had seen indicated that total costs might be known by 2014. She asked if they could get a range of estimates for the next FESAC meeting. Dr. Synakowski responded that he was hopeful when the FY 2014 budget was determined they would be in a better position to discuss the administration's approach to supporting ITER. She asked when the ITER roll-off referred to in charge three and in the facilities charge might happen. Dr. Synakowski responded that a discussion would be forthcoming of the administration's approach and commitment as to how it planned to support ITER.

Dr. Hantao Ji referred to the issue of conflict of interest and noted his agreement with Dr. Greenwald in that it should not be overdone. He noted that many of the people with conflicts of interest would have the best technical expertise. He stressed the importance of being open and suggested that that was one way to manage such conflicts of interest. Dr. Synakowski responded that if a person was taking part in a discussion that would be part and parcel of a dialogue leading to a recommendation that had direct financial bearing on the institute where you would be employed then you would need to leave the room. In addition he stated that members would have to be cognizant of what might inhibit the discussion. He clarified that for the subpanel the members had the obligation to follow the special government employee guidelines for FACA committees. Dr. Ji stated that he felt it was important for the subpanel to be open as a means to control conflicts of interest. Dr. Synakowski stated that the ultimate responsibility, monitoring conflicts of interest, resided in significant part with the designated federal official.

Dr. Ji noted that the facilities were part of the program and the program was itself a part of the strategy or roadmap so the facilities were not standing alone. He wondered if they could determine a good list of the facilities without taking into consideration the whole picture. He acknowledged that could be time consuming so asked how they would proceed. Dr. Synakowski indicated that they were happy to work with the members of the subpanel as they had with Dr. Rosner. Dr. Ji asked if after this exercise would there be time to revisit the strategy. Dr. Synakowski responded they had an obligation to report on the plan.

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Dr. Ji referred to the small facilities and the \$100 million and said it was an abstract figure. He asked if there was a particular reason it had to be \$100 million. Dr. Synakowski responded that the reason was that the director of the SC had stated that. He added that the more members deviated from that figure the more they would run the risk of taking themselves out of the discussion. Dr. Ji asked if they could discuss small amounts of funding or less than \$100 million after the conclusion of the current charge. Dr. Synakowski stated it could be considered but ultimately the charges would come from the SC but personally he thought the idea had merit. Dr. Ji suggested that further collaboration with other departments might be beneficial. Dr. Synakowski responded that he could develop such relationships. He thought that if two departments within the SC came up with a leading idea he thought that would be powerful. Dr. Ji asked about other agencies and Dr. Synakowski noted that would be more complicated. Dr. Greenwald stated that among the Chairs of the advisory committees they had exchanged a general request that if, as the panels worked, it looked like requirements or collaborations across the offices was something they want to talk about then the Chairs were open to that and the individual panels could communicate with each other.

Dr. Synakowski stated that the documentation pertaining to the current charge included the fact that one of the considerations that Dr. Brinkman would use was the directions of other agencies. It would be one of the inputs. He continued that to give an example, if there was a partnership with NSF (National Science Foundation) that would lead to a facility that was being jointly sponsored, that might be regarded as value-added.

Dr. Steve Zinkle referred to the conflict of interest issue and the question of recusal particularly for the FESAC panel and suggested that with today's technology and with it being webcast the requirement to physically leave the room might not be as compelling as it would be if they were conducting the meeting under previous circumstances. Dr. Synakowski responded sometimes the physical presence of someone during a conflicted discussion could matter to those who might otherwise feel themselves to have a minority voice. He considered from a group psychology point of view it might make sense. Dr. Zinkle referred to the facilities issue for the panel and asked based on discussions with Dr. Brinkman, did he think that the collection of facilities should be at the same institution or viewed as a national asset. He asked if they would consider it a credible plan having different physical locations but with a scientific connection. Dr. Synakowski responded he did not have a strong answer on that question but he considered there might be a bias to have certain flexibility on the location of facility.

Dr. Fonck referred to discussion about the issue of a strategic plan and stated he would like to make a distinction between a strategic plan which might be fraught with politics and budgets and a technical roadmap. He stated that he felt they had a technical roadmap in which they could ask the question what should be done for fusion that would inform the discussion regarding the facilities. He thought that what they needed was an exercise that would clarify what needed to be done technically to get from our current standing to where we want to go. He thought it was important to separate that technical discussion from policy considerations.

Dr. Hubbard asked if FESAC members with any association with facilities needed to remove themselves from the room during the discussion of Charge 2. Dr. Synakowski responded that everyone was trying to work through this and to develop best practices. Dr. Greenwald stated that what members had talked about was that people with conflicts, they would separate the charges and particularly Charge 1 and 3

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which were general, separate it out for a separate vote on Charge 2 and people with conflicts covered in Charge 2 would recuse themselves.

Dr. Greenwald referred to the issue of conflicts of interest and the discussions of user facilities. He thought that it was a false distinction. He stated that they should treat users of facilities as if they were customers. He said that the facilities in the SC were unique by design and users would have a long-term relationship with those facilities often including multi-million-dollar programs and staff. He said the notion that there was somehow no conflict was not realistic and not being aware of that would allow conflicts to slip in, in an inconsistent way.

Dr. Raymond Leeper noted his agreement with Dr. Fonck regarding the idea of a technical roadmap to bring clarity. Dr. Synakowski responded that he agreed and that they did have materials for that in the Greenwald report from the Priorities, Gaps and Opportunities: Towards A Long-Range Strategic Plan for Magnetic Fusion Energy, Report of the Fusion Energy Sciences Advisory Committee, October 2007. A member noted that there were a lot of materials out there but it had not been brought to a clear roadmap giving guidance as to sequencing and importance. He said it would be beneficial to have a roadmap that was up to date given the reality of ITER and other issues.

Dr. Kathryn McCarthy pointed as an example to the Office of Nuclear Energy, a nuclear energy roadmap which had been helpful in the program in terms of discussions of this type.

BREAK

The Fusion Energy Sciences Advisory Committee recessed for a 15 minute break.

BRIEFING FROM THE SUBCOMMITTEE ON MAGNETIC FUSION ENERGY PROGRAM PRIORITIES

Dr. Robert Rosner, Subcommittee Chair, University of Chicago

- Acknowledged that this was a challenging exercise and thanked all the members of the subcommittee for persevering and completing the task.
- Detailed the schedule of six meetings held over the period July 2012 to January 2013.
- Referred to advice and information given to the subcommittee. He noted first of all the charge given to the committee from Dr. Brinkman at their first meeting in Maryland.
- Discussed the guidance given at the meeting in October 2012 by Dr. Synakowski with regard to conflicts of interest within the subcommittee. He acknowledged that resolving what the rules were took some time and the committee members observed a hiatus while the issues were resolved and they eventually received a document stating the rules they were to follow.
- Stated that they had input from the community with 62 white papers submitted to the subcommittee's public website.
- Thanked the USBPO (U.S. Burning Plasma Organization) that had hosted two virtual workshops during the deliberation period of the panel.
- Discussed how the group initially had organized themselves for the task at hand. They decided that in response to the three charges that they would set up four breakout groups with each one

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covering parts of the science they felt they would need to be able to answer the charge. He clarified the groups were set up to do the base work not as a response to the charge. The four set up to organize the study were:

- Covering basic fusion science
- Fusion science directed principally at the ITER
- Fusion science in the post-ITER era
- Designated to provide feedback to the subcommittee on the policy implications of the recommendations.
- Discussed how they organized their prioritization of the science based on ReNeW (Research Needs Workshop) into three subgroups and described the focus areas:
 - Subgroup 1 – Foundational science and technology
 - Subgroup 2 – ITER-critical science
 - Subgroup 3 – Post-ITER fusion science
- Reviewed the process of the committee by which they dealt with the issue of conflicts of interest. He stated that they were given a guidance letter vetted by lawyers in addition to Dr. Synakowski's verbal guidance. He noted they had two problems: they had to organize members to ensure that they followed the FACA rules; and they then became aware that they had been operating until the October 2012 meeting without considering themselves as a FACA-governed committee. He noted they were concerned that their discussions were in effect poisoned by the fact that they had not segregated out members with potential conflicts of interest. He stated they decided at that point to push the reset button. They made the following decisions:
 - Identified all subcommittee members' conflicts of interest and published them to all subcommittee members on the private website
 - Decided that the subcommittee would no longer discuss issues regarding FES facilities
 - Decided that the subcommittee would discuss facility issues in response to Charge 2 but only 'non-conflicted' (in fact or perception) members would participate
 - Identified the 'non-conflicted' subcommittee members who participated in discussions leading to the Charge 2 response who were: Michael Brown, James F. Drake, Sibylle Guenter, Mitsuru Kikuchi, Mark Koepke, William J. Madia, Michael Mauel, Robert Rosner, Carl Sovinec and Steve Zinkle.
- Described their perspective on the U.S. fusion program's key goals which he stressed were the subcommittee's views but probably aligned with the SC position:
 - Maintenance of a strong, fundamental plasma science program
 - Insuring that ITER would succeed in meeting its science goals which is a primary objective for demonstrating the technical feasibility of nuclear fusion as an energy source.
 - Establishing that fusion energy is a safe, environmentally sustainable and economically feasible energy source.
- Stated that with regard to source material they used the ReNeW Report regarding magnetic fusion that was published in June of 2009 and listed the other reports that they used. He noted that with regard to the 2009 report most of the basic material had been covered and although there were some new developments they did not see any reason to re-write the report. It was used as the basic for the beginning of discussions. He stated that the ReNeW Report had not ranked the thrusts and so the subcommittee set this up as one of their key goals.
- Discussed their criteria for prioritizing the science described in the FES ReNeW Report. The subcommittee posed the question, does a given thrust:
 - Provide the technical opportunities for breakthrough discoveries and excellent science?

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- Maintain or rebuild critical skills, technologies and competencies for plasma science and fusion research and development?
- Enable U.S. leadership contributions to ongoing international fusion research?
- Address, mitigate and/or solve high risks to ITER performance goals?
- Contribute to informing decisions about the future path of fusion development?
- Noted that discussing these questions led to three groupings of ReNeW thrusts: highest priority; middle priority; and third priority. He explained their rankings and noted that the three subgroups of the panel would by their nature rank the five criteria differently but the selection of the five most important thrusts had been a consensus view developed by all three of the subgroups. He noted that in selecting five as the most important they were aware that the remaining thrusts contained program elements that were also important. He clarified that the key distinguishing element was not scientific importance but rather timeliness in the context of preparations for ITER.
- Listed the highest priority thrusts and noted that research supporting steady-state scenarios was cross-cutting and had connections to each of the high priority thrusts. He added that the listing was not in a priority order and the numbering came directly out of the ReNeW Report:
 - 2: Control Transient Events in Burning Plasmas
 - 6: Develop Predictive Models for Fusion Plasmas, Supported by Theory and Challenged with Experimental Measurement
 - 9: Unfold the Physics of Boundary Layer Plasmas
 - 10: Decode and Advance the Science and Technology of Plasma-Surface Interactions
 - 17: Optimize Steady-State, Disruption-Free Toroidal Confinement using 3-D Magnetic Shaping, and Emphasizing Quasi-Symmetry Principles
- Stated that those five thrusts were considered both of scientific importance and timelessness for ITER impact.
- Listed the middle priority thrusts:
 - 3: Understand the role of alpha particles in burning plasma
 - 4: Qualify operational scenarios and the supporting physics basis for ITER
 - 5: Expand the limits for controlling and sustaining fusion plasmas
 - 14: Develop the material science and technology needed to harness fusion power
 - 16: Develop the spherical torus to advance fusion nuclear science
 - 18: Achieve high-performance toroidal confinement using minimal externally applied magnetic field.
- Listed the third priority thrusts:
 - 1: Develop measurement techniques to understand and control burning plasmas
 - 7: Exploit High Temperature Superconductors (HTS) and other magnet innovations to advance fusion research
 - 8: Understand the highly integrated dynamics of dominantly self-heated and self-sustained burning plasmas
 - 11: Improve power handling through engineering innovation
 - 12: Demonstrate an integrated solution for plasma-material interfaces compatible with an optimized core plasma
 - 13: Establish the science and technology for fusion power extraction and tritium sustainability
 - 15: Create integrated designs and models for attractive fusion power systems
- Discussed each charge as outlined in the letter dated April 13, 2012 from Dr. Brinkman. He first considered Charge 1 and noted “...prioritize among and within the FY2013 elements of the non-ITER

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magnetic fusion portion of the Fusion Energy Sciences program. Assume funding at the FY2013 Presidential budget request level...". He stated that this was not related to ITER but concerned research. He noted that the subcommittee considered themselves in a difficult position as the funding decisions for FY 2013 had already been made and they did not have the ability to dig into the details of that budget to re-allocate funds to different elements. He noted that they thought the FY2013 FES budget level was inadequate to address even the highest priorities in a timely way. He stated that the subcommittee decided that they would state their position on that budget level in several points:

- They felt that FES budget allocation of facilities (10%) and research (45%) was out of balance compared to other SC offices and some of this might be a result of ITER cost overruns.
- They felt that the under-funding of U.S. facilities which were some of the best in the world to address urgent research needs was jeopardizing the success of ITER.
- The subcommittee also felt that it jeopardized the ability of the U.S. to take advantage of ITER in the future because it was undermining the universities' and facilities' ability to attract top minds in the field including high-quality students and researchers who would seek dynamic opportunities abroad.
- They felt it would weaken the preeminent capability of the U.S. program in innovative research and critical discovery science.
- Stated that if that budget level persisted the subcommittee would recommend that a thorough remapping between the high priority thrusts and the elements of the U.S. FES program should be undertaken by DOE/FES.
- Discussed Charge 2 and noted *"...prioritize the elements of the non-ITER magnetic fusion portion of the FES program, but assume a restoration of the budget to the 2012 level..."*. He stated that they decided that they would divide the available funds into three parts:
 - They recommended that one third of the restored funds of \$12 million should be used for a 3-year period of operation of C-Mod to resolve high-priority topics on ITER-relevant issues. In addition C-Mod should be utilized as a critical experimental device as opposed to a long-term facility. After C-Mod has completed its ITER tasks that it be shut down so funding could be reallocated toward high-priority science goals as described in Charge 3.
 - They recommended that \$10 million be allocated to increased utilization of DIII-D covering operations and research focused on achieving faster progress on urgent, high-priority research for ITER preparations. The work on disruption prediction, avoidance and mitigation and ELMs (Edge Localized Modes) was identified as part of the highest priority thrust work.
 - They recommended that \$10 million be allocated to highly targeted support of theory and simulation. This would need to be focused on high-priority research thrusts, advancing specific new physics topics and where appropriate building tools ultimately aimed at allowing broad use by the community. This should be closely monitored.
- Stated that with respect to Charge 2 they expected that within five years there would be a considerable evolution of domestic major facilities that would include the closure of C-Mod and the completion of the NSTX upgrade. He added the program would have to consider next steps in the fusion major facilities portfolio such as possibly an upgrade to DIII-D and a stellarator.
- Discussed Charge 3 and noted *"Prioritize the elements of a U.S. program that has a substantially enhanced emphasis on fusion materials science. Consider the five year period following the roll-off in ITER project construction funding. Assume that the roll-off allows a 50 percent increase in the non-ITER magnetic fusion level of effort during that 5-year period over that in the FY2013 budget, and*

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that research on fusion materials science and harnessing fusion power will capture much of this increase.”

- He stated that for the period following the roll-off in the ITER project construction funding with a 50% increase in non-ITER MFE effort they recommended that the highest emphasis be given to science-rich feasibility issues that would directly impact the path to be followed to a DEMO fusion device. He added that additional resources would also permit moving forward with a Fusion Nuclear Science Program (FNSP) and would prepare the way for a FNSF.
- He noted that at present it was uncertain what materials would be selected for an FNSF, what would comprise the engineered components making up the first wall and what would be the magnetic configuration confining the burning plasma.
- He stated that an expanded program on materials research would enhance two board categories of research: i) fusion nuclear materials effects and ii) plasma surface interactions.
- He provided some specific examples of program elements for an expanded FNSP:
 - Develop materials with micro-structures to mitigate transmutation produced helium and permeation of hydrogenic species
 - Conduct neutron irradiation issues
 - Participate in ITER Test Blanket Module program
 - Extend linear plasma devices
 - Initiate a comprehensive structural materials modeling program to address neutron damage, as part of a DOE-wide research program in the area.
- Expressed some final thoughts on the U.S. fusion program’s priorities and direction:
 - Strongly support international programs and new efforts in materials research but the extent is open to debate.
 - Believe that the decisions affecting the future of the U.S. fusion science program must place first priority on:
 - Maintaining scientific strength in areas that the U.S. has been world-leading.
 - Ensuring continued excellence of the fusion science workforce.
 - Delivering the key science and technology needed for ITER that has been assigned to the U.S. fusion science program.
- Stated that the subcommittee members disagreed with the FY2013 FES budget request that called for an overall reduction in domestic research that would need to be accompanied by a modest increase in funding for scientific collaborations on major international facilities.
- Referred to a slide showing the differences in percentages of funding for facilities and research by each department in the SC. The subcommittee was of the opinion that:
 - The funding profile of the FES was largely the result of ITER’s cost overruns as the U.S. did not have control over its ITER budget contributions.
 - This impact of the cost overruns was anticipated by the U.S. fusion community which had sought the DOE’s agreement that ITER participation would not occur at the expense of the FES research program but this had not come to pass.

COMMITTEE DISCUSSION

Dr. Fonck referred to Charge 1 and the comments and he said that NSAC (Nuclear Science Advisory Committee) had just gone through a discussion of the impact of their own reduced budgets and it looked just as dire as FESAC. He said that NSAC stated that if the budget remained flat or was reduced it

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would be disastrous for the department and then stated the consequences and choices within the scenario. He felt that that had given a better representation. Dr. Rosner responded that in order to do what NSAC had done they would have had to devise a plan given the budget level they were given that was better than the plan that Dr. Synakowski proposed. He said they could not have come to a consensus on a better plan. He said that if anyone wanted to significantly change Dr. Synakowski's plan that his subcommittee was not the one to do that. He noted that their subcommittee had many people on it from various facilities so they would have been severely affected on what they could have changed in terms of budget.

Dr. Fonck stated that if the subcommittee was calling for a remapping then they were implying that what had been presented as a good-faith effort from FES, may or may not have been adequate. He said that in his opinion the subcommittee should have made a first attempt. Dr. Rosner responded that without the option of remapping they would have needed to go into the program elements of the budget and this was something the subcommittee was told not to do. He continued that not having that option open to them they felt they were in a difficult position and could not move ahead. Dr. Fonck noted that the subcommittee should then have made it clear that it was essentially directed away from fulfilling that charge.

Dr. Fonck referred to number one of their response to Charge 1 and suggested that they could change the percentages applying more to research. Dr. Rosner commented on the importance of retaining the research dollars which ensured that the facilities were staffed with highly qualified researchers and to retain the intellectual base. Dr. Fonck also commented on number three of their response. Dr. Rosner responded that this had come from the National Academy directly when it posed the question, what are the indicators of a healthy scientific field. He said that these were: if graduate students asked if exciting things were being researched; did it have a future; and if that future would include a field adequately funded.

Dr. Edward Thomas noted that the workforce report from 2004 laid out a roadmap specifically to address the question mentioned by Dr. Fonck. Dr. Rosner asked if it was Manpower Developments in Fusion and Energy Science. Dr. Thomas responded yes. Dr. Rosner clarified and said he had been talking about a general study done by the National Academy discussing fields of science in general.

Dr. Leeper referred to the issue of qualified researchers and asked if it was any different for the other two budget scenarios in terms of keeping top people involved. Dr. Rosner responded that in response to Charges 2 and especially 3 the issue was not as dire as Charge 1. He noted that the perception of a field in trouble was the closing of facilities and with no option of reopening.

A member referred to comments on Charge 2 and asked if the subcommittee had considered specific targets if they were talking of \$10 million a year in an integrated project as it seemed vague. Dr. Rosner responded that they were thinking of projects that would require monitored progress over a number of years, so not a one-year period.

Dr. Cohen referred to the questions about specificity and he noted that he was on the panel and they were asked to prioritize at various budget levels. He said that the responses to the charges did provide prioritization but it did not provide details or getting into dollar amounts in various parts of the program elements. He said the subcommittee did not know how to cope with that and every member who had

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FES funding was conflicted. He considered it a pragmatic approach to being responsive to Dr. Brinkman's charge. He noted that he supported what Dr. Rosner stated about the philosophy of the panel.

Dr. Greenwald thanked Dr. Rosner and the subcommittee members for all their work on the report. He opened it up to questions but noted that some of the other committee members would also be available in the later part of the afternoon to respond to questions.

Dr. Hubbard referred to the index which noted information about percentages of funding allocated for each department and each category, research, facility operations, future facilities and workforce. She thought that Dr. Fonck had implied the research funding might be too high but she noted that the appendix made clear that that figure was in line with the other programs but it was the construction that stood out as different. She suggested putting a note into the report to clarify that point. She referred to the comments made in the report concerning costs and ITER and noted that the costs had also increased substantially since the decision was first made regarding the ITER project.

Dr. Fonck referred to Charge 3 in which they discussed workforce development and sequencing due to limited resources. He asked if the subcommittee had grappled with the reality of that or whether it had any wisdom. He gave an example and said some years ago they had evaluated whether the U.S. should be involved in the ITER test blanket module program. He said one of the findings was the U.S. hardly had the capability to talk about it as the technology component had degraded so much due to reduced funding. He referred to that situation and said it meant that the U.S. would have to start now working with partners and developing the expertise. He asked how the committee grappled with the fact that it would all be put off until the ITER roll-off. He said that at that stage it might be possible that the ITER test blanket module program would be fixed and there might not be a role for the U.S. Dr. Rosner responded that he was perhaps the wrong person to respond to that question. Dr. Rosner noted that when they would be talking about the materials science aspect he thought that one thing the Fusion Energy Science Program could benefit from would be the fact that the office of Basic Energy Sciences had a robust program and there would be a time when the interaction between the two programs would be much closer than currently existed.

Dr. Greenwald referred to section 4 of the report which covered the findings and recommendations and he recommended that they bring that section forward in the report. He noted that it was not an executive summary but readers of such reports would expect that summary section to be clearly marked. Dr. Rosner responded that he had no objections to that restructuring.

Dr. Ji referred to the charge detailing percentages for each program and stated that it was his understanding that the research percentage should remain high so that experienced researchers were not lost. Dr. Rosner responded that was correct, that you could not reduce funding for research, lose the experienced researchers and still continue to work on projects such as ITER.

Dr. Synakowski stated that he did not want to deny the reality and facts as shown on the table but one should be careful because there were parts of the program where experimental research was performed and did not have an operations line and he referred to general plasma science and the experimental plasma research program so he noted that was a small reality. He acknowledged that what was driving the number to be low was ITER. He added in the near term the NSTX upgrade was being supported in significant part by what normally would be going on the operations line and that was currently not in

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the operations line. He referred to the FY2013 budget and the present run time for DIII-D that represented a static state they were promoting for the future. He said the FY2013 budget request was a snapshot of a dynamic situation and facing the hard proposal in that with respect to a facility shutdown, the C-Mod facility shutdown would lead to the possibility of enhanced DIII-D operations in the future.

Dr. Synakowski thanked Dr. Rosner for the report and thought that the effort the subcommittee put forward in managing the conflict of interest issues was done as well as could have been done. He said the SC would weigh the technical merits of the advice and would view the content from its vantage point. He stated that the advice in the report was important to the SC and assuming the advisory committee was on a path to approving it the SC would welcome the report in its final form. He acknowledged that the SC knew it was a challenging task and he considered that Dr. Rosner had been a gentleman, a scholar and had worked tirelessly and he thanked him.

LUNCH

The Fusion Energy Sciences Advisory Committee recessed for lunch.

PRESENTATION ON THE EU PATHWAY/DEMO STUDIES

Dr. Francesco Romanelli, *Leader, European Fusion Development Agreement, Associate Leader, Joint European Torus*

- Thanked the FESAC for allowing him to present the roadmapping exercise they had done in Europe.
- Explained why a roadmap was needed. He stated the need for a long-term strategy on energy technologies for security of supply, sustainability and economic competitiveness required long-term programming. He noted that within that context fusion energy must become a credible energy source.
- Stated that in line with the European Commission's (EC) proposal for Horizon 2020 and on the advice of the Independent Panel on Strategic Orientation of the Fusion Program there was a need for an ambitious and realistic roadmap to fusion electricity by 2050. He noted that following that proposal a request was made by the EC to the EFDA (European Fusion Development Agreement) for a fusion roadmap.
- Stated that this was possible if a number of conditions were satisfied:
 - The success of ITER in which it is expected to achieve most of the milestones needed for a decision on a demonstration fusion power plant (DEMO).
 - ITER construction has triggered major advances in enabling technologies
 - ITER licensing has confirmed the intrinsic safety features of fusion and they are of the opinion they should follow a similar approach for a DEMO
 - Vast majority of proposed roadmap resources are devoted to the ITER construction and preparation.
 - The assumption is that ITER will be built according to specification and within cost and schedule.
- Related some of the steps forming the background:
 - Fusion Fast Track (D. King, 2001)
 - SET Plan (2007)
 - Facility Review (2008) – A review of the fusion facilities with a ranking done by a panel.

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- AHG on JET and accompanying program (2010)
- DEMO Working Group (2010)
- Strategic orientation of the fusion program (2011)
- Common aspects to these reviews were: the central role of ITER; 14 MeV neutron sources (IFMIF) for material qualification; and DEMO as a single step to the commercial power plant.
- Stated that what they had done was put the roadmap into a logical sequence and within a realistic plan of the elements of the reviews of the last few years taking into account the recommendations of the review panels.
- Confirmed that the success of ITER was the main element for the success of the roadmap.
- Reviewed the present roadmap:
 - Pragmatic approach to fusion energy – Meaning they are not looking for the ultimate technological solution for a fusion power plant. DEMO should be a machine that should work and produce electricity. There should be an avoidance of multiple, critical paths by minimizing new and complex facilities. The roadmap was constructed to have a single critical path and this is ITER.
 - Focus the effort of European laboratories – A Goal oriented approach articulated around 8 Missions with a priority to the items in the roadmap.
 - Ensure innovation through early industrial involvement – Industry would have to take the full responsibility for the commercial fusion power plant after successful DEMO operation. DEMO cannot be defined and designed by the research laboratories alone but needed the involvement of industry. Industry has been involved in the design of the roadmap. Noted that industry needed to be involved in materials development. There should be a reduction of capital costs. He noted that the capital cost of DEMO in 2030 can be shown not to prevent the economic utilization of fusion.
 - Exploit the opportunities arising from international collaborations – Not every facility should be in Europe (but Europe should have all the necessary know-how by 2030 for the construction of DEMO).
 - Increase of support to education and training with 300 PhDs per year and 140 Post-Doctoral positions per year.
 - Maintain a sizeable amount of fund to basic and curiosity-driven research.
 - There are three periods considered:
 - Horizon 2020 detailed work packages and budget. He stated they have a well-defined proposed budget. He said all the Euro figures are only proposed. He said they are still awaiting agreement with the EC, the European Parliament and the European Council about the size of the research program and specifically of the nuclear program.
 - 2021-2030 indicative program and budget
 - Beyond 2030 – presently an outline
- Noted the method of the work was to be reviewed and stated that they had divided the work into eight areas which they are calling missions. For each mission:
 - Critical aspect for reactor application examined, risks and risk mitigation discussed involving experts
 - Level of readiness (TRL) now and after ITER discussed
 - Work packages elaborated
 - Gaps analyzed (or issues requiring new devices)
- Received input from ITER, IO, F4E, EFDA CSU and Associates.
- Noted that industry was involved through the Fusion Industry Innovation Forum.

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- Stated that a bilateral meeting was held at the end of June 2012 and a workshop in July 2012 in which the roadmap was presented to the fusion community.
- Noted there was an assessment by the EFDA STAC.
- Thanked Dr. Zinkle for his excellent contribution to the process.
- Discussed the roadmap in a nutshell and noted that there was a large amount of material that they would release at a later day. He discussed within the context of a timeline of 2010 to 2050 the following areas: Plasma operation; Heat exhaust; Materials; Tritium breeding; Safety; DEMO; Low cost; and Stellarator. He noted that it should be enough for a DEMO decision to start construction in 2030.
- Discussed Mission 1 and stated that there were no major gaps but they would need enhancements of ITER and JT60-SA for increased heating power and operation with a full W wall in preparation to DEMO operation.
- Discussed Mission 2 which concerned Heat Exhaust. He noted that Mission 1 and 2 were closely interlinked and this was reviewed in detail including alternative strategies.
- Reviewed Mission 3 concerning Materials. He stated that for Materials there was an assessment led by the Chair, Derek Stork. He detailed the strategy they were using. He noted that their goal was to have a conceptual design by the end of Horizon 2020. He reviewed some of the results from testing in different phases. He noted that the materials they were considering were the sum of baseline set of materials plus a few risk mitigation materials and discussed the strategy for their testing.
- Discussed Mission 4 which is Tritium Breeding. He noted that the availability of Tritium was something that they would have to carefully look at but was not so obvious an issue of availability because it would depend how much would be needed in DEMO and how much would be used by ITER.
- Noted the next three Missions 5 - Safety, the implementation of the safety feature of fusion in the DEMO design, Mission 6 - DEMO- the DEMO design construction and operation itself and Mission 7 – Low Cost – to ensure low cost of fusion electricity.
- Discussed Mission 8 – the Stellarator, defined a mission to bring the Stellarator to maturity as a possible power plant, a solution. He did not think the Stellarator could be ready in time for the DEMO design.
- Reviewed the human resources they would utilize by 2020 subdivided into four objectives. The objectives are: Objective 1 - build ITER on time and within budget; Objective 2 – Secure ITER Operation; Objective 3 – Train Generation ITER; and Objective 4 – Lay down the Foundation of the Power Plant.
- Noted the financial resources allocated per mission, per year over groups of years. He discussed EC resources required in Horizon 2020.
- Commented on international collaborations and noted that in addition to ITER exploitation and the BA projects there were several other opportunities:
 - The exploitation of JT-60SA in collaboration with Japan for the preparation of ITER Phase 2
 - The construction of a pilot IFMIF plant (Early Neutron Source) in collaboration with Japan within a post EVEDA phase
 - The collaboration on a joint Divertor Tokamak Test facility
 - The collaboration on small scale DEMO R&D (for example making use of the infrastructure developed with Japan during the BA for that purpose)
 - The use of the Chinese Fusion Experimental Tokamak Reactor (CFETR) facility with China and of the Fusion Neutron Science (FNS) facility in the U.S.

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- The share of know-how on the TBM program with other ITER parties whenever a win-win situation is expected
- The use of non-EU research fission reactors
- The collaboration on stellarator lines other than the HELIAS (Heliotron and compact stellarator)
- Noted that Europe could offer to other parties the participation in its facilities and specifically to JET as training facility for ITER.
- Stated that he had not discussed theory and modeling and they considered them part of the missions. He said they had special funds allocated for high performance computing (HPC) and supporting activities. He said apart from that all the human resources were included in the missions or the basic research activities. He added that they thought they needed to increase the resources on material computer modeling to support the material research.
- Said that they considered the roadmap a living document that would be reviewed regularly with respect to physics, technology and budgetary development.

COMMITTEE DISCUSSION

Dr. Greenwald thanked Dr. Romanelli for his presentation.

Dr. Hubbard referred to one of the slides that mentioned an upgrade of ITER and JT60-SA. She asked did this refer to one or both. Dr. Romanelli responded that the best solution would be to have an upgrade of ITER but he cautioned they were not speaking of something in the near term but in the long term, beyond 2030. He noted they needed to understand whether it was feasible or not. He said for ITER they were looking at the possibility of replacing the upper plate with tungsten. He said they would soon know whether that would be possible. He added if that was not possible then they would look at the possibility of doing that on JT60-SA.

Dr. Synakowski referred to his comments on the cost of ITER and then asked what the DEMO cost had to be, or assuming that ITER equals DEMO in some sense in terms of cost not being acceptable. He asked Dr. Romanelli to comment on the thinking with respect to that and how the cost could be brought down or perhaps why the analogy might be a false one. He said if he could respond by starting with ITER as a model for potential DEMO costs. Dr. Romanelli responded that there had been a review of ITER costs completed by the people who had looked at the cost of DEMO and he said their conclusion was that the sanctions were reasonably in line. He said that they could extrapolate from that the DEMO costs on the basis of information that they currently had. He continued that there were specific aspects like the complexity of some components. For example, did they need to make the magnets as they are now or could the manufacture be simplified? He said that definitely this must be a target for them. Dr. Synakowski noted that he agreed with him in that collectively they needed to have an answer that had a solid technical grounding.

Dr. Ji asked if the funding included labor or just research. Dr. Romanelli responded that it did not include ITER. He said the global amount included full personnel costs. He said a lot of the funding was provided by the member states in the EC. He said they were following a participation scheme similar to the existing one.

Dr. Meade noted that there had been significant progress made on the project over the past six months. He referred to Dr. Romanelli's descriptions of DEMO, Phase 1 and Phase 2. He asked where he

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envisioned the switch from Phase 1 to Phase 2 occurring. He asked if the first production of electricity would occur in Phase 1 or 2. Dr. Romanelli responded that the first production of electricity could probably be done with Phase 1 but he added if they wanted to go to a reasonable level of availability they would need to add the second set of components. Dr. Meade asked if they would be producing net electricity with the starter blanket. Dr. Romanelli responded some level of electricity but added they were not in a position presently to give a precise number. He added that the target for producing electricity, the target was before 2050 which would mean that they planned to complete the commission in early 2040 to be ready with the operation.

Dr. Meade commented on the difference between the U.S. and Europe with regard to how both countries envision DEMO. He said that Dr. Romanelli had described DEMO as something that would evolve and improvements would be incorporated as the project went along whereas in the U.S. they had traditionally held that the DEMO is a commercial prototype and once completed there was commercial production thereafter. He commented that the Europeans had a pragmatic approach and this was a good example of that approach in their program.

Dr. McCarthy said when he had discussed the cost target that the DEMO should be at least a factor of 5 less than ITER which was €10 billion. She asked did that include the balance of plant costs. Dr. Romanelli responded that the power plant conceptual study was done during the 90s at a cost of electricity for fusion power of €2 per watt. He said this was for the 10th of a kind so for the 1st of a kind it would be higher. He said in the roadmap they did not specify a number.

Dr. Synakowski noted that they appreciated his effort in presenting to the committee. He acknowledged that he was visiting many countries and they were grateful that he had taken the time to visit FESAC.

PLANS FOR DEALING WITH THE NEW CHARGE ON SCIENTIFIC FACILITIES

PRIORITIZATION

Dr. John Sarff, *Chair of the Subcommittee on Scientific Facilities Prioritization, University of Wisconsin, Madison*

- Noted that his presentation would describe the present position with regard to the new charge outlined by Dr. Synakowski. He added it would also convey their thinking and how they would move ahead.
- Noted the members of the subcommittee and thanked Dr. Don Rej for assisting as Vice Chair. He added that the members of the committee were a good mix of expertise, institutions, lab and non-lab and participants with experience in recent planning activities.
- Outlined the subcommittee's process:
 - The first conference call was January 25, 2013.
 - They drafted a call for white papers and this was circulated January 29, 2013.
 - First meeting of the subcommittee will take place February 1, 2013 at the Gaithersburg Hotel as most were present for the FESAC meeting and for others they would use ReadyTalk for remote participation.
 - Weekly conference calls would be held through mid-March considering their short timeline.

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- They were discussing a possible second face-to-face meeting in late February or early March in the D.C. area as they went from the transition of analysis to writing.
- There would be remote participation (ReadyTalk and H.323) for community input to supplement white papers during February as this had been used by the Rosner subcommittee during the summer of 2012. He noted that Jim DeKock, UW-Madison had offered to help facilitate.
- A website was being planned (USBPO or UW Plasma Physics).
- Advised that they had sent out the call for white papers and the due date was February 14, 2013.
- Stated that the documents pertaining to this call were available on the FES website. He added that the documents presently there were the charge letter dated December 20, 2012, the auxiliary letter from Dr. Synakowski to Dr. Greenwald and 1-page descriptions of the four facilities and upgrades proposed by FES.
- Referred to the white papers and noted that they intended for them to be specific, largely driven by the timeline and time needed to process them. He stated that the list that would be prepared by the SC would be only one page so they were asking people to begin the contraction process. He stated that they had requested a recommended length of four pages or less and they should include references to supporting material and must be self-contained. He added that the papers should be emailed to John Sarff and Don Rej. He indicated that they wanted to make the white papers available to the public on a website and this was something that they would discuss with the authors, as to whether they were in agreement.
- Commented that there was a wealth of information and planning documents that provided a backdrop to this process. He added some included the ReNeW, Priorities, Gaps, Opportunities, the HEDLP and the Rosner Report.
- Discussed the instructions for the white papers:
 - Looking for world-leading science so they were looking for explicit statements as to why proposed facilities would provide that.
 - Description of the facility and if there was impact beyond the FES mission then that would be potentially high leverage and should be noted.
 - The context should be noted with respect to research gaps, needs and opportunities.
 - The context of the facility relative to the world effort in fusion and plasma science research.
 - Provide an estimate of the construction cost, annual operation cost and schedule. Also include an estimate of the value of the existing facility for proposed upgrades.
 - Assess the readiness of the facility using the criteria and categories indicated in the charge letter. The assessment would have to be justified by referring to specific scientific and engineering requirements for the proposed facility.
 - Ready to initiate construction.
 - Significant scientific/engineering challenges need to be resolved before initiating construction.
 - Mission and technical requirements are not yet fully defined.
- Referred to the proposed facilities and upgrades that the subcommittee would be evaluating and noted:
 - Four facilities/upgrades proposed by FES (Step 1 of the charge) including: Materials initiative (two facilities); Fusion nuclear science facility (FNSF); DIII-D facility upgrade; and Quasi-axisymmetric stellarator experiment (QUASAR).
 - Anticipate other proposed facilities described in white papers appearing in reports.
 - Explicit FES guidance that ITER should not be included in the exercise.

FUSION ENERGY SCIENCES ADVISORY COMMITTEE

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- Charge sets \$100 million cost threshold and FES advised that they can consider somewhat lower threshold of \$50 million.
- Commented on the conflict of interest issue:
 - The members have been asked to treat this issue seriously and this request will be followed.
 - The FES arranged for Sue Wadel, the General Counsel for DOE to attend the meeting on February 1, 2013 to advise them on conflict of interest issues. They had also received an email from the General Counsel via Dr. Dehmer that had outlined the expectations.
 - The charge asks for assessments of importance and readiness. He stated that the subcommittee had a voting/rating process and colleagues closely associated with a white paper (or FES suggested facilities/upgrades) would need to recuse themselves.
 - They were anxious to maintain a high level of expertise available for writing a strong report.
 - They felt a need for additional discussion to resolve and understand all aspects of conflict of interest as soon as possible.
- Discussed the subcommittee's report:
 - He acknowledged that there was a hard deadline of March 22nd.
 - He noted that FES had already set March 15, 2013 for the next FESAC meeting date and were requesting a draft report by March 8th to 11th.
 - They wanted to strive for a report that was an inviting and readable format with 1-2 page summaries of proposed facilities and supporting material to provide context.
 - He acknowledged the critical question of the number of facilities was yet to be determined for recommendation in the report.

Dr. Greenwald thanked Dr. Sarff and his committee for taking on the charge with a very limited time frame.

Dr. Cohen referred to his comment that the subcommittee had been asked to assess the importance and readiness of the proposed facilities and asked if it would imply a ranking and if that was the case he was interested in how the members of the subcommittee would deal with the conflict of interest issue. Dr. Synakowski responded that they were asked to comment with regard to readiness etc. but he noted that the ensemble that would go forward and was not to be ranked.

Dr. Nermin Uckan referred to the identification of a, b and c categories and wondered if they were absolutely necessary or useful. She thought that the subcommittee would need those indicators and in a sense that was a prioritization. Dr. Synakowski responded that it is what it is but then they were not asked to go further and assess an order of importance. Dr. Uckan referred to the 20-year report and asked how many facilities they were allowed to consider in that process. Dr. Sarff responded that he could not comment on that question. He stated that one of the things they did was look back to see what had been done previously and for the 2003 report some of the communities did create a process analogous to this charge with some lists and he gave some examples. He said it was ten or more and it provided some point of reference.

Dr. Meade referred to what they had requested as far as information for the white papers. He wondered if it was possible to outline this properly in one page. Dr. Sarff stated the white papers were dealt with in four pages but the end product for the SC would be one page. Dr. Sarff acknowledged it was challenging but they hoped that if it was presented in a compelling way that it would encourage people to want to read it.

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Dr. Zinkle asked if they would have enough time to process input from the community which was not due until mid-February and then only 3 weeks to process that and have several meetings. He considered it a monumental task. He referred to follow-up community input and asked if it would be invited. Dr. Sarff acknowledged that if there was more time they would want it to be an open process so the time deadlines were providing constraints.

Dr. Hubbard noted it was good that the white papers were going to be available publicly as it would give the community access to review what was being submitted which might reduce duplication. She asked if they were picking projects and locations at this stage. Dr. Sarff responded that was correct.

Dr. Ji asked whether they could consider working alongside the other parallel subcommittees in a collaborative way discussing the same thing to finalize the best possible list of facilities/projects for the SC. Dr. Synkowski responded that there had not been any thought about that. He added that it had been expressed that the final analysis would consider the interests of other agencies. Dr. Greenwald also noted that any interactions of committees outside of the SC would be improvising and he did not think that those groups would be in a position to have a formal statement on three weeks' notice with regard to major facilities.

Dr. Hubbard asked if FESAC people would have enough time considering the March 22nd deadline for the DOE and the next FESAC meeting date. Dr. Synkowski clarified that the deadline was for the input to come in but the report would come out in September 2013.

Dr. Thomas referred to Dr. Hubbard's comments about duplicate ideas with regard to submitted white papers and asked how they would proceed with that. Dr. Synkowski responded that they did not view that necessarily as a bad thing as it might represent a strong interest from multiple sources in a certain area which could have influence on what facilities might be built.

BREAK

The Fusion Energy Sciences Advisory Committee recessed for a 15 minute break.

PUBLIC COMMENT

Anne White, Assistant Professor, Nuclear Science and Engineering Department, MIT

- Noted that she was currently doing research on C-Mod, DIII-D and exploring options for international collaborations.
- Thanked the FESAC subcommittee members for their work and report on the Priorities of the Magnetic Fusion Energy Science Program.
- Noted that the FY2013 FES budget request called for an overall reduction of domestic research with more engagement in collaborations on major international facilities. She added the report explained that such an ordering of priorities was a mistake. She agreed with these views.

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- Provided more information about the extreme difficulty with the assumption that international facilities could substitute for domestic facilities in the sphere of education and workforce development.
- Stated that an open letter to the Associate Director of the SC was published in Physics Today. She added this letter was signed by 200 plasma and fusion scientists from inside and outside the U.S. She quoted from the letter: *“The vibrant domestic program must be maintained and nurtured so that today’s graduate students and post-docs can become experienced scientists and leaders 15 years from now. Instead the administration’s FY2013 FES budget redirects one sixth of the FY2012 domestic spending to the ITER project. If this trend continues within the next two years hundreds of scientists and engineers at some of the premier U.S. institutions will be laid off. In the long run this will lead to the permanent loss of some of the brightest young minds from the U.S. plasma infusion program and likely from the academic and research community altogether.”*
- Provided details on the effects of reduced funding on the three major fusion facilities and projects and the resulting effects on researchers and graduate students over several fiscal years’ budgets.
- Indicated that the message was U.S. universities would not be major players in fusion and added that students might leave the country or the field as a result.
- Noted that for students remaining in the field there would be new opportunities and international collaborations but she added that research abroad presented many challenges especially with married couples.
- Outlined the many problems for American students associated with offshore facilities including the fact that many were not built as international user facilities and there was no model to ensure equal partnerships.
- Stressed the importance of excellent U.S. facilities with the capacity to perform ITER-relevant experiments now.
- Outlined how cuts were negatively affecting universities, C-Mod and other key areas.

Earl Marmor, MIT

- Thanked the priorities report subcommittee on their work on a difficult set of charges.
- Noted that the priorities of the ReNeW thrusts were thoughtful, coherent and endorsed them.
- Commented that the report should be helpful in the planning process.
- Stated that he thought the response to Charge 1 was the most difficult. He stated that he agreed with the recommendation that the entire program needed to be re-examined in light of the priorities under that budget scenario.
- Added that the process was not specified in the subcommittee report and he wondered how the remapping would be accomplished.
- Stated that he thought this needed strong community input.
- Acknowledged it was time-sensitive in that the FY2014 budget proposals were being currently negotiated and in that context he noted it was constructive to remember the recent FESAC advice: *“This does not appear to be the time to make termination decisions that cannot be reversed. We are not clear on the wisdom to do lasting changes to the program based on an undefined ITER profile and in the absence of an overall plan for the program.”*
- Stated that the situation had not changed substantially since that FESAC meeting.
- Referred to Charges 2 and 3 and discussed the main issues and recommendations.
- Urged OFES to take serious account of the important findings and recommendations in the report particularly in the iteration process for the FY 2014 budget and in planning for FY2015 and beyond.

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Miklos Porkolab, MIT

- Stated that he would like to make some comments on the subcommittee's report.
- Thanked them for recommending that C-Mod funding be restored for another five years to explore critical near-term ITER relevant issues relating to Thrust 9.
- Disagreed with recommendation that C-Mod should be shut down after five years as it was not relevant.
- Stated that in his opinion it was relevant and suitable to explore Thrust 13, steady state, by having ITER and DEMO relevant lower hybrid current drive technique with unique features including the relevant frequency 4.6 GHz at the ITER and DEMO relevant magnetic field $5.4 \geq$ Tesla, Power/R=(6MW/m) and metallic walls which make C-Mod unique.
- Noted how an upgrade would make C-Mod more relevant and requested that after three to four years of operation they should be able to submit a proposal and have it peer-reviewed for an upgrade.
- Stated the training of scientific and engineering manpower of the future should be a top priority of a long-range R&D program such as FES.
- Noted that now they were in the process of selecting student applicants for graduate school for the fall in nuclear science and engineering referred to by Anne White and the physics department which he was representing. He compared figures of graduate students in the U.S., Europe and China. Noted the high numbers in Europe and China and the declining numbers in the U.S. educational system. He discussed some of these figures within the context of shutting down C-Mod.

DISCUSSION OF THE REPORT FROM THE SUBCOMMITTEE ON MFE PROGRAM

PRIORITIES

Dr. Martin Greenwald, FESAC Chair and FESAC Members

- Stated that with respect to the report the committee needed to reach closure before the conclusion of the meeting and he suggested that the people from that panel in particular Dr. Don Rej and Dr. Charles Greenfield come to a microphone in case there were questions.
- Suggested that they do a round of questions, comments and assessments that would be pointed toward a resolution.
- Said they did have to have a vote and they had discussed how that would be done in terms of dividing out the Charge 2 answer from Charges 1 and 3 due to the conflict of interest issue.
- Stated that they then had to prepare a transmittal letter if they approved the report so time had to be allotted for that.
- Said that he wanted to begin the process by hearing from everyone individually with their overall assessment and suggestions.
- Asked Dr. Fonck to begin the process.

Dr. Fonck stated he found the charges challenging and the time was too short given the importance of the questions. He thought that there were valuable elements in the report but he considered it not quite up to the level of a FESAC report. He stated that he did not think Charge 1 was answered. On

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Charge 2 he felt with a modest increase in budget of \$30 million or 10% the sky was not falling. He thought there was an incongruity between the tone and statements regarding Charges 1 and 2. He thought it was out of context in time. He explained that it was admirable that they said the first five thrusts they chose from the ReNeW panel were their first priorities but he felt their real priority was preparing for ITER. He noted that it was not logical to be concerned about short-term problems impacting ITER whereas they had chosen priorities that were long-term for periods of ten years without a modification of those priorities as the program evolved. He thought there might be things in the second set of thrusts that might be more relevant to ITER operations.

To summarize he thought there could have been more thought on the timeliness of issues and the flow of priorities. He noted that he did not like the framing of one of the groups being called, post-ITER. He thought it was better to use, complementary-ITER science. He thought it should be clear it was financially post-ITER not logically post-ITER. He referred to Charge 3 and said that they appeared to be picking out priorities for a materials technology program and he considered the logic deficient. He did not think that the whole technology program could be thrown away and then rebuilt in ten years after the roll-off occurred. He indicated that he would not be supportive of sending it forward at the current stage.

Dr. Hubbard said that there was a lot to like in the report. She considered that they had grappled with the difficult charge of prioritizing the technical work which she considered very valuable. She said they had laid out appropriately the reality that with Charge 1 and the current budget situation they would not be able to fulfill the minimal obligations of the top priority things they were committed to. She added that although it would have been nice if they had remapped it, it might have been that they didn't have the information or the mandate to complete that. She agreed with but wanted to see more clarification of the primary recommendation from Charge 1. She said that the technical rationale going from the first part of the report to Charges 2 and 3 could have been clearer as some steps were missing there. She added that she would be following the lead of some panel members and would not comment on Charges 2 or 3.

Dr. McCarthy noted that she had a hard time relating the results of the report with the charge itself. She said she agreed with Dr. Fonck's assessment and added that what she thought the report needed was a concise executive summary. She found that in looking at the report in whole there was an unevenness to the report, in that in some places there was sufficient specificity and in other areas that was lacking. She said the message that came across to her was that prioritization could not be achieved as the budget levels were so low. She indicated that prioritization could be done at any budget level and what would change was the line and what would end up getting funded. She stated that if you could not say what the most important thing was then the plan itself was not good. She added that the report should state clear impacts because that would inform priorities and give the FES and SC the justification to argue for an increased budget. She thought that the report viewed ITER in a negative light and thought the community needed to embrace ITER even if it was in a different country and to recognize the opportunities it would provide current researchers and students in the future.

Dr. Ellen Meeks stated that she thought the report did a good job of pulling priorities out of a range of possibilities and she acknowledged it was a difficult task. She agreed with the previous speakers that there was a lack of expressing clearly the consequences of the different levels of funding. She said the three different charges represented the different levels of funding but she felt it was not stated clearly

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what you would get and not get for those different levels of funding, so not a good cost benefit analysis. She added that increased clarity and an executive summary were both needed in order for it to adequately speak to the people who had asked for it.

Dr. Ji stated it was easy to critique such a report but it should be acknowledged that it was a really difficult job. He said he was present at the first two meetings asking for community input and he considered it was very challenging with the charges asking tough questions. He said perhaps they should ask, how could the report be better? He said he would prefer to address the areas in which they did a good job and to improve the bridge and look at the conclusions. He referred to Charge 3 with detailed discussions concerning Thrust 5 which he considered the most important and timely. He said from that point how would one arrive at conclusions and that was what he did not see in the report. He said they should have a chance to present the process, their logic to FESAC and other people in the community. He said that the conclusion(s) were problematic and he would like to see the process and thought that giving the subcommittee that opportunity was fair. He referred to how the Europeans approached such issues in which they viewed the bigger picture, stating that the facility was part of the program and the program was part of the roadmap. He thought that looking at the bigger picture might help and he considered that approach was missing in the U.S. Dr. Ji said that finally he wanted to see a more positive excitement generated for young students and researchers to bring them and their enthusiasm into their programs, whether by new facilities or discoveries and new challenges in programs. He considered that important.

Dr. Meade acknowledged that it was a very difficult and important task that the panel was given. He stated that his overall view of the report was that it was not yet finished. He thought that some parts needed to be completed before FESAC could accept it. He referred to Charge 1 and stated that it was the chance to describe the effects of the reduced budget going from FY 2012 to FY2013 and the impact continuing at that budget level would have on the program. He said it would be extremely damaging and thought that more examples would have helped to make the case. He said as the report would help to determine decisions on the FES budget more specificity was needed in the response to Charge 1. He said that he watched the webcast of the NSAC review of their panel's report for a similar charge. He stated that they had laid out clearly the options of what they would have to deal with and do from a programmatic point of view. He thought it extremely important that as budgets decreased that they be able to show priorities clearly.

He thought that with Charge 2 there was increased specificity on what needed to be done. He referred to the allocation of \$10 million to a highly targeted support of theory and simulation and asked if that was sufficient to do anything of significance. He stated that the panel tackled one important thing and that was over the time period there should be an evolution of U.S. fusion facilities. He referred to Charge 3 and commented on various elements of the response. In one section of the response he said the report noted the issue of participating in the ITER test blanket module should the opportunity arise. He noted that the question there was that the opportunity was now and the question would be are we or aren't we going to be a participant. He expressed concerns over some of the terminology used. In summary he thought the report was a good start establishing the priorities and issues but they would need to be connected to the responses to the three charges.

Dr. Uckan stated that many of the members of the committee had commented on issues that she had marked in the report. She thought the charge given to the panel was a difficult one and she thought

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they had done an admirable job but she thought it was an unfinished task and was an incomplete story that needed some clarification. She thought that they needed to provide specific responses to the specific charges. She noted that the selection of priorities were present and they had provided good justification for selecting those priorities but then they should have been tied in a better way to the specific charges and that was not clear. She added that an executive summary was needed. She noted that she agreed with the suggestions given by previous members of committee.

Dr. Richard Callis noted as Dr. Uckan had, that many members had already expressed many of his comments. He said he agreed that there was a lack of response to Charge 1 and a strong need for an executive summary with clear definition and recommendations. He referred to Charge 3 and stated it was difficult for him in reviewing that to determine the priority items. He thought that a chart at the beginning stating the priorities of the 18 ReNeW thrusts grouped into three areas should be included and if there had been a theme for each one (for example the report stated the theme for the first five was near-term ITER needs) that could have been put on one page, one chart and it would provide a clearer oversight of their position. He thought organizing it in such a way would facilitate the SC if they wanted to be able to look at the bigger picture.

Dr. Frederick Skiff noted that it seemed to be a long time since it was perceived that the field of fusion energy was considered to be expanding. He said the report was good but painful in that it was difficult to face a report that would detail priorities but state that at low funding levels many of those priorities would fall away. He stated that cutting even small percentages of 10% could be felt by programs if they were already operating close to the edge of the cliff. He noted that this situation was making it difficult for the committee. He thought that many programs would have to cease that were excellent. He said that as he was involved in a university he was sensitive to how the field of fusion energy was seen by other branches of physics and the pipeline for talent. He thought that although he was not directly involved in the decision he thought the shutting down of C-Mod did not make sense because of the huge impact and he thought it was relevant. He indicated that he agreed with many of the public comments made.

Dr. Thomas said that the committee had been challenged with not only budget constraints but also that FESAC had been tasked for many years with the development of a priority process. He added that comments could be made on the report about having a clear line of justification for some recommendations but he felt they should be commended for taking on a difficult challenge of trying to determine a clear process for prioritizing activities within the program. He added that taking the budget into account with the domestic side of activities so tight it made the process very painful. He said when the report is forwarded to FES he said they should consider the report from a university perspective because the decisions and recommendations would have strong impacts on the next generation of researchers. He noted that students viewed the current developments in the field as extremely discouraging and he thought that should be kept in mind.

Dr. Leeper acknowledged how difficult a problem it was to address these charges. He noted he could see the logic where they had gone back to ReNeW and had delineated five of the top issues and had noted the issue of timeliness in getting the work done. He said there was a physical reality that they were dealing with and he thought that some of the thrusts noted outlined very difficult problems and they had worked on some of them for many years. He stated that for ITER to be successful those problems had to be solved and he thought the report made the case that the U.S. had some of the best facilities

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for attacking some of the those problems but the thought that none of the budgets made sense for the amount of work that they needed to do. He established his concern about that issue.

Dr. Leeper referred to Charge 1 in which they referred to existing problems that had to be resolved and had then stated that they only had the budget to run the facilities at a 10% level. He noted that did not meet the reality test in his view. He said that the U.S. facilities could impact some of the difficult issues and he said that the facilities should be run full-out to solve the problems. He stated if not, how would they move forward with it? He stated for Charge 1 the response was incomplete and they needed to specify more impacts. He thought they should state in strong language that if the stated problems were not solved then ITER would not be a success. He said with regard to Charge 2 with the allocation of \$32 million he could state how the committee had made the case about how they would spend the funds. He said he did not like the statement that said once C-Mod had completed its critical ITER relevant tasks it should be closed down. He did not see how they could predict that ahead of time and he said they did not know how that would go. He stated that did not make sense to him. He referred to Charge 3 and said that he foresaw so many problems in Charges 1 and 2 that they might not get there anyway. He emphasized that in his opinion people were everything in solving these problems and that the workforce should be protected.

Dr. Greenwald noted that he appreciated the prioritization, that fact that the committee took on the task and made the hard decisions with a strong consensus. He agreed that the response to Charge 1 was incomplete but he thought that it just recognized reality and this opinion had been expressed by other members of FESAC. He said they had made four findings effectively about the impact. He stated they could have been more specific but noted there were dire consequences and these areas included: the health of the program; bringing new people in; and the success of ITER which were all in jeopardy. He thought they had recommended a necessary step of how to deal with that reality and he thought omitting details was perhaps appropriate. He said he would not address Charge 2 due to conflict of interest issues. He referred to Charge 3 and acknowledged that they had made a good start and the new charge given to FESAC meant they would have a new panel considering that set of issues in detail. He said that he would now like to hear the comments of the subcommittee members who were present to hear their comments on where FESAC could and could not go under the circumstances.

Dr. Zinkle noted that the conflict of interest issues were a major distraction to the subcommittee and that made it difficult for them to do their work. He said from his perspective the best part of the report was being able to reach a consensus on the three tiers of the ReNeW thrusts. He thought that the report might not have conveyed the amount of work and quantitative scoring that went into that. He said the lack of a fusion roadmap was a major hindrance for the work of the subcommittee. He thought in hindsight they should have taken it upon themselves to come up with a straw-man roadmap but noted it was difficult to prioritize if one did not know where they are going. He thought that in order to address the charges they should have come up with a straw-man roadmap in the early stages.

Dr. Cohen noted that the subcommittee had proceeded as professionally as anyone could want. He acknowledged where they could not satisfy committee members' desire for a more complete response to Charge 1. He said he did not think it was possible for a subcommittee that had experts within the field and are affected by funding recommendations to come up with such recommendations without having conflict of interest issues. He referred to Charge 1 and said the basic conclusion was after careful consideration of all things that needed to be done for the science and for ITER was the fact that you

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could not get there on the \$250 million budget and that was in the report. He said that it was the opinion of the subcommittee members that to lay out priorities within the five highest priority thrusts for what could be done for \$250 million was inviting doing even more damage to fusion and plasma physics research in the U.S. He added that they did not want to facilitate an approach of down-selecting and focusing on a few areas. He said that was his perspective on how the subcommittee arrived at its approach to the charges and in particular Charge 1. He stated that if they had taken another six months on the report it might be 10% improved and would miss all deadlines on the budget process and on having any impact and therefore he would consider it a waste of effort for talented people. He suggested that they file an interim report and then go back on whatever time scale is thought to be reasonable.

Dr. Charles M. Greenfield noted he would respond to some of the general themes that he had heard discussed. He referred to Charge 1 and acknowledged they had difficulty deciding on the best way to answer the charge. He noted that many members had gone into the process thinking that they would be very detailed with particular facilities and he referred to Dr. Rosner's response to a question which stated that many members had conflicts of interest. He said that without considering their first few meetings where conflict of interest issues had not been quite so formalized many members felt there were many instances where they could not go there. He said that in order to come up with a set of detailed recommendations for Charge 1 he thought the committee would have to be reconstituted with no one with conflicts of interest. He said about half of the members had conflicts of interest. He said they had done a lot of detailed information on budgeting for each activity so they could be mapped to the high priority scientific elements that they had identified and basically felt that they had to go in and redesign the program. He said also, as pointed out by Dr. Rosner, at the \$250 million a year level for the domestic program he thought it doubtful that they would have done a better job than the office had already done. He said that if that was their funding level then they would have to do some realignment of the program with the priorities they had noted.

He referred to Charge 2 and said he could not address this because of a conflict of interest. He said the response to Charge 2 was crafted by a small group in the subcommittee and most of the members had left the room while that discussion took place. He referred to Charge 3 and acknowledged the comments of Dr. Meade which suggested some re-wording but he thought what was important to realize when discussing actions in the future was consideration of general themes of what kinds of tasks FESAC might want to be doing ten years in the future. He said he had taken detailed notes of the committee's comments which he would then forward on to all members of the subcommittee. He said they had always intended subsequent to the meeting to make some corrections where there were factual problems and change some inconsistencies but noted they were not planning on a major re-write. He said if FESAC members thought it important they could re-address some of the issues in Charge 1 but not about their recommendation but about consequences of the current situation and make it more detailed. He said they could also go back to the subgroup that had responded to Charge 2 and ask again for more detail.

Dr. Don Rej acknowledged that what Dr. Zinkle and Dr. Cohen had said was important in that it was very difficult to answer Charge 1 when there was no strategy or priorities already laid out. He referred to Dr. Meade's comments and noted that that was the difference between what he had heard at the NSAC as opposed to what he had heard from Dr. Rosner. He acknowledged that it was difficult coming up with priorities as it was all about trades. He referred to other departments where there was a ten-year plan

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that was renewed every five years. He considered that ReNeW was a great place to start as it showed what was needed but he stated that a catalogue was not a strategy as it did not show priorities or give a timeline. He referred to Charge 1 and noted that at the beginning they had stated that even the top priorities could not be done. He said with respect to Charge 2 he also recused himself. He referred to what had been written with regard to Charge 2 and agreed about the importance of noting consequences and said they would report that comment back to Dr. Rosner and the other committee members.

Dr. Greenwald noted that hearing the different opinions of the FESAC members it should be appreciated how difficult it was for the subcommittee to complete its work and reach a consensus. He said that given what they had heard from the subcommittee and from FESAC and given the timeliness of getting the information to Dr. Brinkman, Dr. Synakowski and the SC who needed it, it was important to proceed. He noted that they always allowed minor changes etc. to go forward but he stated that there were a few slightly more substantive changes that FESAC agreed could be considered as part of their mandate. He said the changes he considered important were to pull out the content of section four and re-write that as an executive summary. He noted that an executive summary did not have to be two or three pages but a summary of the main findings and recommendations. He said it could also be called a summary of findings and recommendations. He noted that he considered that the heart of the answers and thought it should be up front. He said that there was a suggestion made by several members, as an introduction to section three, to include a summary of the prioritizations and he considered that would be very useful. He said that those were the changes he was asking that they vote on if they agreed.

Dr. Greenwald continued that his recommendation was to forward the report noting some of the comments and stating that the process was incomplete but that the report did suggest a roadmap for moving forward and that FESAC was suggesting that Dr. Brinkman carry that out. He asked for comments.

Dr. Ji thought the executive summary should be non-technical so that there would be an increased understanding among the broader community.

Dr. Uckan asked what dangers or problems might result from an incomplete report. Dr. Synakowski responded that advancing something close to what had been done would in and of itself be useful. He said it would be less than useful to hold back on the report. He said recognizing the deficiencies was fine but he thought that it was fair enough and understandable to point out the strong feelings pertaining to the budget and what the consequences were in a negative sense but he thought there needed to be a constructive aspect to ensure that there was something, even in a broad sense, that says and therefore and would lay out the process from that point. He elaborated on the dangers of having a position where a department would say they cannot move forward on \$250 million a year and starting a process of remapping a new way forward. He discussed another model used where they would have a group of senior people who would be explicitly un-conflicted, either retired from the field or demonstrated a wide expertise or leadership in the sciences and after an intense course of the nature of the program and its needs would be presented with information from advocates and make their case. He said there was value in considering that approach.

Dr. Fonck noted that the subcommittee and the process it went through might have benefited from a more traditional process for FESAC to work with them. He acknowledged that they were assembled and

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had a tough charge and were given a short timeframe to complete that problem and the conflict of interest issue added to the problems. He said that it did not seem right considering the magnitude of the problem. He said it might have been preferable for them to come to a certain stage and then come to FESAC and say, this is our current position, this is what we struggling with, and provide details. He said that at that stage FESAC might have been able to give some input. He said the fact that it had been done extraneous to any discussion appeared to be creating problems. He felt that many of the critiques were centered more on technical rather than substantive issues. He noted that he felt there was a paradigm shift and that the report was suggesting a certain path and that the essence of the program should be near-term support for ITER and that would affect the whole program and he wondered if FESAC members had considered and agreed with that.

Dr. Greenfield said that he wanted to address the apparent contradiction between what the community said and the recommendations for thrusts that supported the physics program of ITER. He said that when they began they were instructed not to consider ITER when they prioritized the program and he said what that meant was the ITER program which was to build a piece of hardware in France would sometime in the future become a research device for their program. He said that the building of this hardware in France was not to take over the physics program. He said that their research was largely targeted at being able to successfully make use of the hardware after its completion. He said that both in the instructions the subcommittee was given and in the way they carried out their research they had separated those into two things so he said in his opinion there was no contradiction.

Dr. Meade referred to Dr. Greenwald's process of moving forward and noted that the FESAC panel was not happy with aspects of the report and he hoped they would look at those issues and revise the report and bring it back to FESAC for a final look. Dr. Greenwald noted that he understood but he had also heard from the panel who had said they had worked on it for three-quarters of a year and did not feel they could make much progress in a short amount of time. He continued that from Dr. Synakowski's point of view there would be value in forwarding the report. He noted that the report recommended a step, not how it should be done, but a step to take them further. Dr. Meade noted it was a FESAC report. Dr. Greenwald noted there were some substantive changes. He asked Dr. Meade if he was recommending substantive changes to the report which would be new work. Dr. Meade responded that he wanted to see the final document that would go forward. Dr. Greenwald stated his original suggestion which was substantive changes in the answers to the charges and that would be new work. Dr. Meade said he thought they should be challenged to consider that. Dr. Greenwald noted that the subcommittee felt that they could not do something substantive. Dr. Meade responded then otherwise they had not answered the charge in his opinion.

Dr. Ji suggested that the report needed to have an improved explanation of the process as the technical work had been done. Dr. Greenwald said he wasn't sure what he was recommending and responded that the members of the subcommittee had said that in part because of the difficulty but also because of conflicts of interest and the challenge of constituting a committee of experts who did not have conflicts of interest they had gone as far as they could go. He added that could be explained in the transmittal letter.

Dr. Meeks asked if they had to do all three charges in one document as the main problems were occurring with Charge 1. She asked if that could be delayed. Dr. Greenwald said that although Charge 1 was incomplete what they were hearing most strongly from the members of the subcommittee was that

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that was the area from which they would be the least able to make further progress. Dr. Meeks said that in making an observation it seemed the response to Charge 1 was that if we have this level of funding then ITER is doomed. She suggested that they did not want to state that position so instead they preferred to walk on the edge and state it was jeopardized. She said you cannot walk that line especially as it referred to Appendix III that called out an imbalance in facilities which was basically saying too much was being spent on ITER. Dr. Greenwald stated that he would take the subcommittee at their word that they had considered their words and under that scenario the success of ITER was jeopardized. Dr. Greenwald asked any of the four subcommittee members present if he was interpreting that correctly.

Dr. Rej responded that if it had come across as a lack of enthusiasm for ITER then they would need to re-read that. He explained that part of the evaluation criteria was making ITER successful, not just the U.S. living up to its technical and financial obligations. He said that he agreed with what Dr. Greenwald had said in that where were the technical risks. He mentioned several problematic issues and noted that the domestic program was focused along those issues and using the existing facilities and they had tried to bring that out in the report.

Dr. Greenfield referred to the report and stated that he had wanted to use different wording substituting “puts at risk” instead of “jeopardizes”. He said there was broad agreement on the subcommittee about the importance and value of any ITER research program to our community and he said the sense they wanted to give was that not doing enough in some of the stated areas, in particular thrust 2 where the U.S. is world-leading, did put ITER’s success at risk. He said in addition there were other areas where the U.S.’s ability to get benefits from ITER was put at risk. He said they would look at their language to ensure that that point was clearly put across. He said they had not meant to call into question the value that they saw in having ITER but if the community could not get to ITER then somebody else would get the benefit and the U.S. would not.

Dr. Ji suggested an interim report. Dr. Synakowski stated that there was value in accepting the process for what it was and perhaps pointing forward in general terms of things that needed to take place with respect to first, Charge 1 and if it is a persistent feature of our budget futures then some sort of assessment of priorities, of the present mapping ought to be done. He said the subcommittee could decide how that was done as there were several different models ranging from engaging FESAC, engaging the national academies to have it be a federal process. He said that there should be some acknowledgement that the conflict of issues may have had some say on how deeply the subcommittee could have gone, for example in Charge 1. He said they should consider the utilitarian value of where the subcommittee was now and where it might be a few weeks in the future.

Dr. Greenwald proposed that they take a vote on whether or not to forward the report. He said that he had a draft of a letter but before proceeding with that he asked if there was a majority. He said he was not asking for unanimity and they would note the number of minority votes. He said it would be a vote on the FESAC report and acknowledging minor changes, including an executive summary at the beginning of the document and summarizing the prioritization.

Dr. McCarthy noted that she thought some parts of the report needed to be rewritten for her to feel comfortable going along with it.

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Dr. Greenwald suggested that he would like to forward the report with a specific set of changes that they would outline including the suggestion made by Dr. McCarthy and recognize in the cover letter that it is incomplete and there would be a process to follow on process. Dr. Synakowski suggested that there be an understanding that those who would be recusing themselves from Charge 2 when they are voting to approve or not approve they are referring to Charges 1 and 3.

Dr. Greenwald moved to accept the report with minor changes with more substantive changes of moving section 4 into the front of the document and doing sufficient re-wording without changing its substance so that it is a viable executive summary and at the front of section 3 summarizing the prioritization in either a table or simple description and then to explain this process in a covering letter. It was seconded by Dr. Cohen. The votes for the motion were 10 for and 4 opposed.

Dr. Greenwald asked if this could be seen explicitly as a 10 to 4 vote, they could be mum on that issue or go with a consensus. He said they would then prepare a letter. He reviewed the letter:

PREPARATION OF A LETTER TO DOE TO CONCERNING COMPLETION OF THE CHARGE ON MFE PROGRAM PRIORITIES

Dr. Dr. Brinkman,

The Fusion Energy Science Advisory Committee transmits its report addressing your charge of April 13, 2012 on priorities in the Magnet Fusion Energy Science Program. We want to thank Professor Rosner and members of the panel for their efforts in taking on this difficult task.

As requested the report proposes a set of scientific priorities for the program target over the next 5-10 years. It then attempts to map those priorities on to major program elements under the three funding scenarios presented in the charge. The challenge of meeting the priorities under the budget assumptions especially the reduced funding assumed in charge 1 is spelled out in the negative consequences that would flow from that scenario as outlined. **The context for this report is a fusion energy sciences budget well below the levels required for a healthy and vigorous program.**

FESAC acknowledges that the answers to the charge are incomplete. But given the Conflict of Interest COI guidance the panel as constituted was unable to provide greater detail. The report does propose an approach toward that goal in its recommendation under charge 1.

The study generated wide-ranging and lively discussion at the recent FESAC meeting after which the full committee voted 10 to 4 to endorse the report given COI concerns, members with institutional conflicts recused themselves from any position on charge 2.

ADJOURNMENT

The Fusion Energy Sciences Advisory Committee Meeting was adjourned for the day at 5:00 p.m.

FUSION ENERGY SCIENCES ADVISORY COMMITTEE

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Minutes created by Granicus, Inc.

Reviewed by FESAC members, speakers, and the DFO

Certified as correct by:



Dr. Martin Greenwald, FESAC Chair

4/10/2013
Date