FESAC Meeting Minutes - December 6-7, 2018
North Bethesda, Maryland

THURSDAY, DECEMBER 6, 2018

Welcome and Introductory Remarks – Dr. Don Rej, FESAC Chair

- Welcome and thanks to FESAC members. All members are in attendance, including three ex-officio members. Thanks to speakers and all who are in attendance at the meeting, and those participating remotely.
- Thanks to committee member Kristina Lynch whose term ended.
- FESAC welcomes two new members whose terms run through June 2021: Tammy Ma and Erik Trask.
- Thanks to the continuing members of FESAC.
- Undersecretary Paul Dabbar will attend the meeting tomorrow providing the Office of Science perspective; this will be one of the highlights of the meeting.
- FESAC has been given a new charge which is community-driven; a long-range strategic plan for fusion energy sciences.
- There have been three recent National Academy of Sciences studies being conducted at the request of Fusion Energy Sciences (FES):
    1. ultrafast laser study
    2. strategic plan for U.S. burning plasma research
    3. decadal study of plasma science
- The FES Committee of Visitors (COV) report will be reviewed, voted on, and considered for approval.
- Thanks to many FESAC members who joined the COV subcommittee.
- There will be presentations at this meeting on the FES Roundtable on Quantum Information Science and on the Fusion Prototypic Neutron Source Workshop.
- Anyone can sign up at the registration desk to make a public commit.

DOE/FES Perspective and Plans, including Presentation of FESAC Charge – Dr. James Van Dam, Acting Associate Director for Fusion Energy Sciences

- Please sign up at the registration desk outside, there is also coffee available.
- This is a new location for the meeting; it is a brand new hotel, and thanks for finding the location of this new, modern hotel.

- Thanks to FESAC members and all the participants.
- Professor Close had to resign from FESAC, and Professor Lynch has rotated off the committee. We are extending a welcome to the two new members - Tammy Ma and Erik Trask.
- We have had two years of healthy budgets, thanks to Congress. This has allowed us to move forward on many long standing gaps and to launch new initiatives. FES appropriations for FY18 and F19 have enabled acceleration of the FES program - including:
    - ITER
    - DIII-D
    - NSTX-U
    - LaserNetUS
    - MPEX Facility
    - Theory & Simulation
    - Private-public partnerships
    - QIS
- We are coordinating with private/philanthropic activities
- The FES program addresses several Administration R&D priorities and practices.
    - American leadership in emerging technologies
    - American energy dominance
    - Managing and modernizing R&D structure
    - Maximizing agency coordination
    - Partnering with industry
    - Technology transfer
    - Workplace training and education
- Following is the status of our solicitations:
    - Funding Opportunity Announcements (FOAs) have not been announced yet due to changes in the SC FOA approval process
    - Issuing FOAs before the funding year may not be feasible
    - The annual "open" SC FOA is always active
    - Please check SC and FES Funding opportunities pages for updates - (https://science.osti.gov/grants/FOAs/Open)

Programmatic updates -

- FES research is carried out by a diversity of U.S. institutions.
    - 38 universities, 11 industry institutions, and 11 laboratories.
- Good progress has been made towards the NSTX-U recovery; they are going into the early design and early procurements. The CD-2 review to firm up the baseline is scheduled for February 2019. The Office of

Project Assessment (OPA) looked at cost, schedule and scope, and the laboratory's capability to perform the recovery and resume operations. Part 2 of the review was the scientific mission need that was reaffirmed during the Orbach-led DOE OPA subcommittee review.

- DIII-D
    - Currently in LTO (Long Torus Opening)
    - Co/counter of neutral beam modification project and three other current drive methodologies
    - Increase reliability
    - Healthy FOAs
    - Frontier science experiments for basic plasma science: high profile presentations, positive engagement so far
- Remote tools are being made available to U.S. institutions to facilitate international collaboration.
- Disruption mitigation with shattered pellet injectors on JET is a U.S. world leading capability and is going very well.
- There are nine FES SciDAC multi-institutional and inter-disciplinary projects jointly funded (a record number).
- FES is exploring opportunities in QIS (quantum information science). A meeting was held in May 2018 to identify how fundamental science supported by FES could advance QIS development, and explore QIS applications that could have transformative impact on the FES mission. There were six priority research opportunities identified.
- The materials plasma exposure experiment (MPEX), a new MIE project, has been launched.
- Fusion Prototypic Neutron Source Workshop
    - This topical area has stalled somewhat due to high cost of IFMIF – still 100s $M
    - Workshop focused on nearer term step, and low cost option based on existing facilities
    - Minimum requirements identified
- A new intermediate scale user facility with dusty plasma research was awarded in 2018, over three years, to Auburn University.
- There has been a partnership with NSF for 21 years; over $8 million was funded by FES in 2018. FES funded a renewal with UC-Berkeley on antihydrogen research, also the Basic Plasma Science User Facility (BaPSF) at UCLA.
- FES established LaserNetUS in FY18 in response to the NAS report recommendations. The network provides broad access to state-of-the-art

facilities for the entire community. The first annual meeting was held in August at the University of Nebraska that included a poster session.

ITER update

- U.S. contributions to ITER are now more than 50% complete. The ITER Organization in France is more than 55% complete towards first plasma, fabrication, and delivery. The progress is going great, and the tokamak complex continues to take shape. A comparison from February 2015 to 2018 shows great progress in construction of buildings. The first machine component was brought into the ITER tokamak pit in November 2018.ITER contracted to use U.S. coil fabrication for its central solenoid. In May, there was a special ceremony of the final delivery of Japanese superconductor for the ITER central solenoid.

Program planning

- The reports from community workshops are very important. FES strategic choices are informed by community and advisory committee input.
- FES is responding to the recommendations of the National Academy report on intense ultrafast lasers.
- The interim report of the burning plasma study by the National Academies of Sciences was issued in December 2017. The final report is expected by the end of 2018.
- The National Academies of Sciences has launched the decadal assessment of plasma science. Professor Kushner, the co-chair, will discuss this further during the meeting. There are multiple Federal sponsors including DOE, NSF, and DOD.
- The 2018 Committee of Visitors will be reporting in a later session. The FESAC charge was to provide an evaluation of process, quality and standing, and project management. Thanks to the COV panel members and the co-chairs.
- A new charge to FESAC is being issued to undertake a new long-range strategic planning activity for the Fusion Energy Sciences program.
    - The report should provide recommendations on the priorities for an optimized FES program over the next ten years under varying scenarios of budget growth, assuming the U.S. will continue participating in ITER.
    - Fusion program prioritization will adapt the High Energy Physics and Nuclear Physics processes
    - Phase 1 – community-led activities coordinated by APS-DPP

- Phase 2 - FESAC subcommittee to produce the report using community input with a target completion date of December 2020.
- The report will be socialized with leaders on Capitol Hill

- Stakeholder briefings - Congress wants to hear cohesion and coercion from us. We need your participation and consensus on the plan. FESAC worked hard twice, but the plans lacked broad consensus. Congress wants to see that we have prioritized items - so please keep this in mind. We want the community to be fully involved in this planning progress. We must and will succeed this time. A bickering community gets no funding; we need to have a cooperative community that speaks with one voice. I think Under Secretary Dabbar will stress these same points. Please welcome Under Secretary Dabbar with open arms and open ears.
- Reminder: Language in H.R. 589
  - Not later than two years after the date of enactment of this Act, the Secretary shall submit to Congress a report on the fusion energy re search and development activities that the Department proposes to carry out over the 10-year period
  - In order to develop the report, the Secretary shall leverage best prac tices and lessons learned from the process used to develop the most recent report of the Particle Physics Project Prioritization Panel of the High Energy Physics Advisory Panel
  - We hope that no member of the Fusion Energy Sciences Advisory Committee sha ll be excluded from participating in developing or voting on final a pproval of the report

People

- The 2018 Nobel physics prize for CPA led to development of high power lasers for HEDP - Arthur Ashkin, Gerard Mourou, and Donna Strickland won the prize.
- There was an investiture ceremony at Buckingham Palace (October 11, 2018) for Knights Bachelor, Professor Steve Cowley "for services to science and to the development of fusion energy"
- DOE senior leadership updates
  - Paul Dabbar was sworn in as Under Secretary for Science - November 2017
  - Chris Fall was nominated for Director of the Office of Science - May 2018
  - Kurt Heckman is a senior advisor in the Office of Science. He will work with the incoming Director of the Office of Science

- FES staff updates
    - Mark Foster - phased retirement status - July 2018
    - Sam Barish - phased retirement status - December 2018
    - Jeff Thomas - joined FES in September 2018 - new ITER program manager
    - Guinevere Shaw joined FES in December 2018 - will manage the fusion nuclear science portfolio
- FES early career awards - 2018
    - Sam Lazerson (PPPL), Tammy Ma (LLNL), Alex Zylstra (LANL), David Donovan (U. Tennessee), Kentaro Hara (Texas A&M), and Nate Ferraro (PPPL)
    - Among 25 of the FES early career awardees, 12 of 14 have achieved university tenure
    - FES early career awardees have also received other recognition
    - The CY 2018 FES post-doctoral researcher program awardees were Marlene Patino (UCSD), Anton Neff (ORNL), Jacob Nichols (U. Tennessee), Ben Faber (U. Wisconsin-Madison), Reed Hollinger (Colorado State U.), Ryan Sweeney (MIT), Luke Stagner (GA), and Noah Hurst (UCSD)

Q&A: Dr. Van Dam

Q. Dr. Wirth: Thanks for the overview. You have been acting Director for 15 months - are there plans to hire a permanent director?

A. Dr. Van Dam: This is being left for the incoming Office of Science Director, Chris Fall. There is verbal approval for two additional hires.

Q. Dr. Demers - One of the reasons P5 has been effective is due to mutual respect. The fusion community needs to believe that FES will make funding decisions based on the community's wishes.

A. Dr. Van Dam: At the next FESAC meeting, Jim Siegrist of HEP will attend and show the funding profile since the P5 report, it is distinctly trending upward.

Q. Professor Walker: Going back to budget, will this budget level be sustained?

A. Dr. Van Dam: Yes, we have had very good budgets, we try to be careful so that projects will have security. For FY20, we just don't know. We will continue to work the process and be ready for what comes.

Q. Professor Verboncoeur: For P5, we developed a training/internship program - aging engineers. Is FES also thinking about this?

A. Dr. Van Dam: We are lowering the average age with recent hires. H.R. 25 had language about workforce development. The youth are our path forward.

Some laboratories including PPPL are working on workforce development and bringing in younger scientists/engineers.
Q. Professor Terry: Open solicitations are being used as a stop gap—how long will this need to be employed? Will this happen regularly, or will there be delays?
A. Dr. Van Dam: It helped that a budget was approved before the end of the fiscal year. The process for this has changed under the new Administration. We are hopeful that under Under Secretary Dabbar will speed it up considerably.
Q. Dr. Reyes: How will workshops be organized? It will be helpful to make connections with the fusion engineering community as well. They should feel included in this effort, and we want to have full agreement.
A. Dr. Van Dam: They are the lead and will be very involved in this process. The American Physical Society has been directed to reach out. The decadal assessment will take care of this. Plasma science is a broad area; fusion energy is a specific application that involves physics, engineering, and technology. We cannot proceed without the technological progress as well.
Q. Professor Pedersen - Thanks for a nice overview. Can you tell us more about private-public partnerships? What is the size of the program, when will this start, and will this be open to laboratories and universities?
A. Dr. Van Dam: Private sector money has been coming into fusion, and this needs to be developed further, and we should take advantage of this. We are considering this and learning from NP on this despite lower TRL levels. We are looking at a GAIN voucher system for FES.
Q. Dr. Patello: When is the NSTX-U timeline target date, and when may it be up and running again?
A. Dr. Van Dam: Critical decisions are being assessed. CD-2 is important to assess the cost, schedule, and scope. In February, a baseline review will be held, which will lead to CD-2 approval. It is premature to say when CD-4 will occur.
Q. Dr. Knowlton: How should the community proceed during the two-year community process? Will people in the community start pivoting their programs more aggressively?
A. Dr. Van Dam: One of the reasons for sending out a letter to the committee transparently is to let people know what is happening. We have released the FESAC charge. We have an opportunity and an obligation to discuss programs that are valuable. In the charge letter, there are three budget scenarios; we start with the FY19 enacted budget.
Q. Dr. Neilson: Please comment about fusion engineers and the strategic plan. Engineers typically do not come to the workshops, so there needs to be

proactive outreach to get their input. The SOFE conference in June 2019 in Jacksonville is an opportunity.
A. Dr. Van Dam: We asked the DPP Executive Committee to reach out to the different committees.
Q. Professor White: Recognizing the importance of junior scientists and post docs, please comment on fellowships for graduate students.
A. Dr. Van Dam: We have a program for graduate students, SCGSR. Curt Bolton manages that program, and it has funding.
Q. Dr. Ma: What do you envision the FES and FESAC roles will be responding to the ultrafast lasers report?
A. Dr. Van Dam: The report is being taken very seriously. It was publicly released, and our program office is being a big part of the response. LaserNetUS is one step; there are more activities ongoing and a lot of site visits.
Q. Dr. Lumsdaine: From a technologist point of view, there appears to be a bit of schizophrenia in the office. FES sits in the Office of Science, but there is an energy drive associated with success. Are we only doing science? How do we deal with that tension?
A. Dr. Van Dam: Yes, there is a tension here. Also, Theory and Experimentalist tensions exist. It all comes down to plasma science. We are actually a big field. The Navy, the Airforce, and NASA all support plasma science. When we get to the application, we may need to move it out of the Office of Science at some stage.
Q. Dr. Groebner: What is the strategy for SciDAC, whole device modeling, and individual codes?
A. Dr. Van Dam: I am not an expert. John Mandrekas is the expert. It is a framework project moving towards whole device modeling; time scales, space scales, and exascale. We are moving towards that direction very fast.
Q. Dr. Greenfield: Private partnerships have been discussed, but you also mentioned philanthropic efforts. What does that mean?
A. Dr. Van Dam: I have met people who are interested in investing in the fusion program. They do it for the pure love of the program. Matt Miller epitomizes that.
Q. Dr. Demers: At times, there has been an emphasis of energy, and at other times there is an emphasis on science. To have a unified voice going forward, is it more advantageous to present ourselves as a community focusing on science, or as a community focusing on energy?
A. Dr. Van Dam: We are the Office of Science. With this strategic planning exercise, we will concentrate on both. If you look at our budget structure, a large part of the budget is burning plasma science. We are also a steward of

discovery plasma science and need people to go back and forth between communities. We are a full-fledged program.
Q. Male FESAC Member (name not known): Is BES supporting MPEX?
A. Dr. Van Dam: MPEX will be a user facility, and we want it to be open to people as a user facility. BES has a large materials program which is high radiation, high heat flux. This will be FES driven. Phil Ferguson will tell us more about that.
Q. Dr. Carter: Do we have opportunities and resources to coordinate LaserNetUS?
A. Dr. Van Dam: It is a collaboration open to user facilities. A workshop was organized; we expected 25 people, and 150 people showed up.
Q. Dr. Carter: Following up from Anne White on graduate fellowships, this is different from the older program. That program had a broader impact and allowed students to work at Universities instead of at a National Laboratory. Is that still the case, or will the program be resurrected?
A. Dr. Van Dam: We need subject matter experts teaching young people to become subject matter experts. For early career awards, we are still working on this, and it is in progress.

MORNING BREAK

Q&A: Dr. Van Dam (continued)
Q. Dr. Carter: What do you see about prioritization among the different elements? How do we go about this?
A. Dr. Van Dam: You can see our budget structure, cross cuts, themes, and topics, which is how the foundations of plasma science workshops were conducted. A process can involve both - in matrix form.
A. Dr. Van Dam: There is an annual budget process - we talked with OMB in December. In February, the budget was released from the President to the Congress. We have leadership within DOE that is engaged with our program. We are asking the community to be involved in planning. There is annual input into this program of community activities. If you need any help, anything you need, please let us know.
Q: Dr. Demers: Are you encouraging us to be key people in that process?
A. Dr. Rej: Let's see how DPP lets us know what we should do - whether we are observers or presenters. We want to be experts and have the right balance. The whole community will nominate people.
Q. Dr. Demers: How do we spend our travel funds to attend these meetings as personnel working on the contracts? Do you anticipate restrictions in participating in the process?

A. Dr. Van Dam: Be mindful of conflicts of interest; we need to have the experts.
Q. Dr. Greenfield: There have been several FESAC panels; results were crippled or watered down. FES has said they are working on this.
A. Dr. Van Dam: We must avoid prior failures. We have to work with General Counsel to make sure they approve of the process. HEP had people shuttling into and out of the room. Recently, it was worse and there were only a few people. We need to find a middle ground where we can get work done.
Q. Dr. Groebner: The workshops are not a guarantee we will get there. Is there a strategy to get people to work together with a coherent strategy?
A. Dr. Rej: Both NP and HEP had physical and virtual town meetings. For consistency, they asked for structured white papers which will inform prioritization.
A. Dr. Newman: We did our selection of seven people with a matrix of diversity and then did a sub-selection from there. We were looking for people who work well together and put their views aside; that would be an inclusive process. We want to make sure that everyone has had their voice heard so that this can become a cyclical, successful process. We try to get to the next level down for who would run workshops.

FESAC Charge on Long-Range Strategic Planning Activity –
Dr. Don Rej, FESAC Chair

Q&A: Dr. Rej
Q. Dr. Maingi: Concerning the snowmass meeting, when will the decision be made to go which route?
A. Dr. Rej: We have not made that decision yet.
A. Dr. Newman: This is up to the community; DOE, FESAC, and DPP are not rushing the progress. We do not want to tell the community how this should be done. This is envisioned to be a cyclical process.
Q. Dr. Neilson: From the community process, what was accomplished and delivered was a set of strategic element white papers. There were some building blocks and the strategic elements, but they were delivered later than what we would have liked. We fell short because we did not come up with a strategy. The community was not ready to speak as one. We really needed to have a process to hammer out the consensus stance.
A. Dr. Rej: The community did self-organize. Please keep in mind that the meetings were to inform the community about burning plasma and maybe

encourage the community to do self-organization. Subsets of the community should start to self-organize given the charge.
Comment by Dr. Van Dam: We know NAS appreciated MFE community input and used all the input with gratitude. We asked Dr. Maul to come to this meeting to give us a status report.
Q. Dr. Knowlton: Would the organizers consider using facilitators whose job is to ensure that the community identifies its values and mission, and ensures the group identifies strategic priorities? This may make the final process a little smoother.
A. Dr. Newman: Two of the seven leadership members have brought up the question about a facilitator.
Q. Dr. Patello: We should also have someone who can record minutes so members can focus on science content. Is there a concern about workshop fatigue; are you getting fresh ideas?
A. Dr. Newman: Yes, there is a lot of workshop fatigue. We should make it clear that the work is not a repeat of prior work but a continuation. This is a different process; from the bottom up—not top down; therefore, a palpable feeling of inclusion. If this is done as a bottom up process, it will allow people to feel that all ideas are being accepted and make it a positive experience for the whole community.
Q. Professor Pederson: How do we get the early career people engaged? We should keep in mind that there is a possible conflict of interest with non-mainstream ideas due to future career issues and proposals. There may possibly be a closed session so they may speak up and speak out in a more "safe" environment. It is important to engage younger people and bring in more ideas. The idea of a facilitator is minor, but it is critical that it will involve the people who will execute the plan.
A. Dr. Rej: For the P5, virtual meetings were held and post-docs and graduate students were invited. The intention is for the next generation to own the final plan.
Comment by Dr. Newman: At the Madison and Austin meetings, the most inspiring part was when the young people were giving presentations. On this leadership group, we were careful to include the young, middle, and senior scientists. This was done intentionally to ensure that their voices were going to be heard and to bring in the young scientists.
Q. Dr. White: I reiterate the importance of external facilitators. Another question is about the charge language. It does not require continuing operation of DIII-D and NSTX-U as user facilities.
A. Dr. Van Dam: Everything is on the table. The charge letter was shown to Dabbar. NSTX-U and DIII-D were included. The charge is comprehensive.

A. Dr. Rej: We will continue the questions before we adjourn; thanks for these good questions.

NAS Decadal Assessment of Plasma Science (presented remotely) - Dr. Mark Kushner
Co-Chair - University of Michigan, Dr. Gary Zank, Co-Chair – University of Alabama

Thank you for the opportunity to discuss the decadal study.

- In spite of the importance of the upcoming FES study, NAS studies are very influential.
    - The 1995 Decadal (led by Prof. Cliff Surko) led to the establishment of the NSF-DOE Partnership program.
    - The 2007 Decadal (led by Prof. Steve Cowley) noted that no single Federal agency was taking responsibility for the health of plasma science. So, the recommendation led to DOE broadening focus on plasma physics, but DOE was not the single lead.
- At our kickoff meeting in October, the federal sponsors spoke about the impact of the past decadal studies. It was striking that NSF had no action on the 2010 study due to the lack of an NSF specific task. We will debate how specific to be with respect to individual agencies.
- The statement of task for the 2020 Decadal is generic to all decadals. We are taking a liberal view of international collaborations and large facilities. This does not map to all areas of plasma science, rather the charge involves the entire spectrum of collaborations, small-scale and large.
- We should not alter recommendations of prior NAS studies, or the Decadal strategy for solar and space physics. For example: Should the Decadal endorse citing ITER on the back side of the Moon? My answer is to read the additional requirements in our charge.
- We have been briefed on the forthcoming burning plasma report in closed session. We see no difficulty incorporating those recommendations into ours. It will not be an issue.
- When the Decadal charge was made, the FES planning study was not yet announced. It has now been launched. Dr. Van Dam, David Newman, and I have had discussions on how to coordinate both studies. We have come to a good understanding. The studies will be collaborative. We will ask some fraction of the community to contribute to both. White papers can be sent in both directions. We do not want to create an additional burden on the community. White papers and testimony for Decadal will be open to the FES planning study. The charges are somewhat different.

Dr. Van Dam and I came to a comfort level about the charges. The FES planning study is operational, whereas the Decadal is more executive. The Decadal has no intention to tell a federal agency how to spend its budget or what solicitations to issue. The FES planning study might do so. The Decadal will present to the entire breadth of the plasma community about high-level science questions to direct the field. There will be no calls for proposals or how budget allocations should be made. The Decadal and the FES planning study will be completely compatible with each other.

- The major proposed theme for the 2020 Decadal is Relevancy. Plasma topics that will garner support are those that
  - (1) address important fundamental science challenges,
  - (2) address national needs, and
  - (3) are relevant to something else, not just interesting science. Relevancy does not mean that everybody works on applications, but that fundamental science challenges are appreciated and relevant to other activities. An example is the figure about common-day applications of low temperature plasmas in the 2010 Decadal report. This is one example of relevancy.
- Four additional members of the Decadal committee have been nominated and are awaiting approval (in the areas of High Energy Density/Inertial Confinement Fusion, Magnetic Confinement Fusion/Computation, Non-Neutral Plasma, and Atomic/Molecular/Optical).
- The audience for the Decadal study is much broader than that for the FES planning study.
- There is a very interesting new trend in that the private sector and foundations are funding paths for fusion. This will be a new audience for the Decadal.
- We plan to hold open meetings in January, April, and July.
- We have an aggressive timeline. The final draft of the text of the report is due by the end of October 2019. This is dictated by our budget. I think that the schedule will slip. But, even a slip of six months means it will be done before the FES planning study, and hence will be available for use by the FES planning study.

Dr. Van Dam: If the Decadal study needs additional financial support to go longer, FES can help.
Dr. Rej: We have time for questions.

Q&A: Dr. Kushner

Q. Dr. Cauble: There is some complementarity with the FES planning study. The timelines are different. But, the community might be confused between the Decadal and Planning processes. Should they be differentiated?
A. Dr. Kushner: There are differences, but they may be too fine grained. The intent is to be as inclusive as possible; the decadal study is broader than the FES planning study and will be at a higher level. The Decadal wants to collect whatever the community gives. I do not want to prescribe that certain types of input go to the Decadal and other input goes to the FES planning study.
A. Dr. Newman: Input to the meetings will be used both for the Decadal and the FES planning study.
Q. Dr. Trask: Will there be more movement, more specificity since the last decadal study?
A. Dr. Kushner: The NAS Board on Physics and Astronomy discussed that last week. The BPA would like to see actionable recommendations. Hence, there will be more such recommendations in this report. We were influenced by what was said to us by NSF at our first meeting. We do not want to be detailed in prescribing how many dollars etc.., but we do need to task agencies.
Q. Dr. Greenfield: I am confused about role of magnetic fusion energy in your recommendations; your committee has little expertise. How will MFE show up in your report?
A. Dr. Kushner: I encourage you to look at the call for white papers on the web site. There are some specific requests in a particular format; accomplishments, current plasma science issues, what needs to be done to address these issues, etc… The NAS burning plasma study had a very specific charge. That charge was encompassing to the entire field of MFE. The committee was true to that charge, about the path to MFE, and was not fully encompassing for plasma science. We will draw from the burning plasma study.
Q. Dr. Greenfield: Many of us wrote white papers for the burning plasma study. For the Decadal, should we resubmit the same ones, or will you use the burning plasma study white papers?
A: Dr. Kushner: We would appreciate receiving your white papers directly. I will check with NAS what we can access from the burning plasma study. But, the charges of the two studies are different, so we might extract something different from your input.
Q. Dr. Rapp: Will you cover how low temperature plasma processing can have interactions with fusion edge plasma effects?
A. Dr. Kushner: Yes, we will address those topics.

Statement: Dr. Van Dam: Thank you for leading this. We were disappointed with NAS that it took so long to get altitude in this process. The final report will not be until the end of the calendar year.

LUNCH

Discussion and Consideration for Approval of FESAC Committee of Visitors Report - Dr. Gertrude Patello - PNNL

FESAC Committee of Visitors (COV)

- The charge was assessing 1) the efficiency and quality of the processes used to solicit, review, recommend, monitor, and document applications, proposals, and award actions; and 2) the quality of the resulting portfolio, including its breadth, depth, and national/international standing.
- Six FESAC members were on the COV.
- We kept the material in the front of the report at a high level. The details are in appendices.
- Here are some of the findings:
    - Using panel reviews is good; however, the panel members do not have to input individual reports into PAMS. National labs are not providing annual reports.
    - There is no list of publications from Early Career awardees. PAMS should be able to produce this. We suggest having Early Career awardees report their publications in PAMS.
    - The good budgets for FY18 and FY19 did not enter the period evaluated by the COV. In the COV period, the FES budgets were on a downward decline.
    - We had an extra week after the COV onsite meeting to access PAMS in order to finish our report.
    - The DIII-D decisions were well documented. These should be a model for other parts of the office.
    - The most recent Measurement Innovation solicitation encouraged research on the edges, a little risky, trying to get traction on a new idea. FES might consider using this approach in other subprograms.
- In summary:
    - FES has good processes in place for soliciting proposals.
    - There are opportunities in place for improvement, such as documentation.
    - FES is understaffed.
    - A validation cross cut could improve the program.

- FES could strengthen its processes for documentation of selections/ declinations and monitoring of awards.
- COV focused on management of the NSTX-U recovery effort.

Q&A: Dr. Patello

Q. Dr. Carter: Did issues with timing of the Funding Opportunity Announcements come up in the discussions?

A. Dr. Patello: We saw more issues with the timing of when funding comes in; often, a larger impact is late Congressional appropriations, leaving no time for a formal FOA process. Program managers, therefore, used the SC Open Call. Also, some FY18 money was diverted to an existing FOA.

Q. Dr. Wirth: I am generally supportive of FOAs, but do we need competition for labs with unique capabilities? The lack of reporting from national labs is noted. Was the OV given access to the fusion materials progress reports?

A. Dr. Demers: We modified the wording of the recommendation to say "when appropriate." We recognize there are some topics where labs have key capabilities that are unique. Also, we modified the recommendation to say "is suggested." We did not have the semiannual materials reports; however, we did have a presentation by John Mandrekas, who discussed them. We were informed about them, but did not have access to them.

Q. Dr. Van Dam: Recommendation 9 is seeking clarification. Does this fit the charge accessing processes within the office?

A. Dr. Demers: We modified the original recommendation. Originally, it gave the connotation that we were trying to strategize for FES, but that was the charge for the COV. But, in these three areas, the projects are distributed among national labs; there are also university and industry projects, which use national laboratory capabilities. We could not identify the interconnections. How can the COV assess whether this is being managed effectively? We need to assess the productivity of the university versus that of the lab. Mixing is going on. It was difficult for the COV to unfold this. We need documents to capture the interconnection.

Q. Dr. Maingi: When reading the draft report, there were no FOAs. Is there any explanation for this?

A. Dr. Patello: There was one FOA in the COV period previous to the period we evaluated.

A. Dr. Demers: The ratio of Field Work Proposals to FOAs was very high in these three areas. Each area is an independent area of research, with different program managers, but we were tasked to look at them all. Some of the programs funded here are unique. In the period of the previous COV, there

was a solicitation with a large number of proposals, which led to a large burden on FES; this effort was disproportionate to the funds available.
Q. Dr. Carter: I was on the COV two times ago. It looked like the same report; namely no FOAs in this area for years. But, if we want to grow this area, we need to provide opportunities. We understand the cost and burden, but we should try to grow this program by opening it up to new projects.
A. Dr. Demers: We are not trying to harm the program or make more work for the people in the program. The benefit of FOAs is that it makes these areas of research more visible to the community. Then, more collaboration and use of abilities will occur.
Comment: Dr. Rapp: It would be helpful to have a table to clarify the funding streams - how projects are awarded, completed and monitored. How much money flows through the Open Call?
A. Dr. Patello: The COV answer to Dr. Rapp would be no. Bu, this report is now transitioning from a COV report to a FESAC report.
A. Dr. Van Dam: If you want the information, we can get it to you.
A. Dr. Cauble: Funding rules have changed. I am not sure that the numbers would be that meaningful to anyone looking at this a year from now.
A. Dr. Rapp: It does not have an overview of the information. I realize that it may be too much work. But, this is a recurring criticism in Group 4. Hence, this is just a suggestion.
Comment: Dr. Greenfield: Give FES feedback to improve the process in the future. I am not sure that going through the effort to produce the table is helpful.

A motion was made (person unknown) to approve the COV report. It was seconded by Brian Wirth. Discussion of the motion follows.

A. Dr. Demers: Is there a roadmap by FES to help them monitor and manage these programs?
Q. Dr. Knowlton: Can you communicate this recommendation?
A. Dr. Demers: The original recommendation is worded as a map. We tried to re-word it; perhaps FES could make a statement on the original recommendation wording, or should it be struck from the document?
Comment: Dr. Patello: Please read the original document.
Comment: Dr. Demers: Does FES want to comment on the original wording in the document?
A. Dr. Van Dam: This is a different nature from the other recommendations. Our suggestion was to put the statements in the report, but not as a recommendation.

Comment: Professor Pedersen: The COV is worried about lack of transparency in a few cases. It becomes difficult to meet the charge as given. The community should have said that they did not have all of the information. I think it should be a recommendation.
Q. Dr. White: How should Recommendation 7 from group 4 be applied? Is it just in the area of group 4?
A. Dr. Patello: This was specific to group 4 only.
Q. Dr. White: Has the community discussed rebuttals or responses to reviewer comments?
A. Dr. Patello: That topic was not discussed.
A. Dr. Van Dam: We follow the Office of Science policy and practice. It used to be done and hasn't been done as long as I have been at DOE. We encourage you to have full discussions with the program managers when you receive reviewer comments.

All in favor to approve this report as is:
18 yes
0 no
1 abstention
Motion passed.

Dr. Patello: Thank you to FES and FES staff on this process.
A. Dr. Van Dam: Thank you very much for all of your hard work regarding this report. Thanks to Nirmol Podder who led the FES preparation for the COV review. Admittedly, national labs are not yet included in PAMS. This is purely an issue of cost. It will happen eventually. The COV, led by Drs. Patello and Skiff, did a professional job. Gert is so organized! We appreciate that the COV boiled down their recommendations to fewer than ten. Last time, the COV report had more than 40. The current COV recommendations are reasonable and doable.

AFTERNOON BREAK

Report on FES Quantum Roundtable on Quantum Information Science
Dr. Thomas Schenkel, Chair (LBNL) (participating remotely from Australia) **and Bill Dorland, University of Maryland, Co-Chair**

- Roundtable Charge - to explore the unique role of FES in the rapidly-developing interdisciplinary field of Quantum Information Science (QIS):

    - Identify fundamental science supported by FES that could advance QIS development; and
    - Explore QIS applications that could have a transformative impact on FES mission areas, including fusion and discovery plasma science.
- Goal: provide FES with a set of priority research opportunities that can inform future research efforts in QIS and build a community of next-generation researchers in this area.
- The findings of this roundtable meeting will be summarized in a report that should be submitted to FES within a month after the meeting.
- The questions of QIS are long term and have great scientific depth as well as technology impact potential across many areas.
- This is an opportunity for FES to deeply engage where QIS dimensions can become an integral part of the research portfolio.
- Avoid hype, lead with science (as always).
- Basic research needs workshops?
    - QIS for FES
    - FES for QIS
    - Pilot program
    - FOA?

Q&A: Dr. Schenkel

Q. Professor Terry: 10^5 cubits are required for what plasma problem? When could such a size quantum computer be realized?

A. Dr. Schenkel: I do not think that question can be answered yet.

A. Dr. Dorland: At the Roundtable, we had representatives from industry and the quantum community who have built systems with 50 cubits. But this is far from a general purpose quantum computer.

Q. Dr. Ma: Is there any effort put into experiments into parameter space or to the other technologies that needs to be?

A. Dr. Schenkel: That is opening up now.

Fusion Prototypic Neutron Source Workshop - Dr. Phillip Ferguson - Oak Ridge National Laboratory

(Dr. Ferguson is the Division Director for Fusion and Nuclear Materials; he is also the Director of the Virtual Laboratory for Technology.)

- FES organized this workshop with the help of the VLT.

- The FY19 budget request included language about a study to evaluate options for neutron sources to test materials in fusion-relevant environments.
- Is there room in this space for the U.S. to do something impactful?
- DONES takes out one accelerator beam line; it is only half as capable as IFMIF.
- We don't want flux gradients across the face of the fusion material sample.
- Japan is considering the Advanced Fusion Neutron Source (AFNS), which is similar to DONES.
- China has produced a neutron source: high-intensity neutron generators (HINEG-I). They have upgrades in mind; HINEG-III might be a gas dynamic trap.
- We are considering an intermediate step to IFMIF/DONES/AFNS with a moderate cost option.
- How small can we make it?
- Richard Nygren started working on a U.S. IFMIF in 1977 (the IFMIF plan is uncertain).
- We want to enable a CD-0 process.

Q&A: Dr. Ferguson

Q. Dr. Knowlton: Less than $500M cost - we are trying to get smart and look at things.

A. Dr. Ferguson: I would like to see something on the order of $100M. Accelerators have been built for other applications. We can do a ballpark estimate.

Q. Dr. Neilson: The importance of fusion materials has risen; there is now better awareness in the community. It makes me nervous to insist that it has to be cheap—it could be cheap but worthless. We should not discuss cost now; that will follow from what needs to be done.

A. Dr. Ferguson: We need to have a good feel for the cost range for CD-0.

Q. Professor Terry: Why was there no follow up on ENS?

A. Dr. Ferguson: I'm not sure. I think people were fixated on the full IFMIF facility.

Q. Dr. Groebner: you want to use the source to calibrate the codes and then use the code to find materials with good fusion characteristics. Is this the general idea?

A. Dr. Ferguson: Yes - this is the general idea. Brian Wirth can help with this question.

A. Dr. Wirth: We have used available neutron sources and some tricks to induce helium damage. But, these data are limited. Instead of waiting for IFMIF (a "Mercedes Benz"), we should jump start with something less ambitious to validate our understanding, refine our knowledge of best materials, and calibrate the codes. We should do things rapidly.
A. Dr. Ferguson: On a log-log plot, we only have data so far from RTNS and fission reactors. Having some points from ITER would help, but we need to go way out farther in He atomic parts per million (appm) and displacements per atom (dpa).
Q. Dr. Newman: What about the Phoenix Nuclear Lab neutron source?
A: Dr. Ferguson: Phoenix is a spinoff from the University of Wisconsin and is mostly for military use (active interrogation). It is allied with Shine (for medical isotopes). The challenge is having enough neutrons to get to 10 dpa. Phoenix has an accelerator, so the cost is modest.
Q. Dr. Rej: What is inhibiting CD-0?
A. Dr. Ferguson: CD-0 is a statement of mission need (in the 413.3b process). Part of that is a cost range and an estimate of how long it would take to build it. But, it has no down-select. The ranges can be large.
Q. Dr. Neilson: The cost range is done at CD-1. CD-0 is the mission need, which means the scientific questions and the high-level requirements. You are almost there already. CD-0 would allow release of resources to do conceptual design.
A. Dr. Ferguson: I would hesitate to do CD-0 without some rough estimate of cost.

Continued discussion of the new charge to FESAC

Q. Dr. Rapp: The charge is to develop priorities, not a roadmap. I personally prefer a roadmap to be part of it; fusion energy drives that. How are science and technology enabled? Is a roadmap excluded or possibly included?
A. Dr. Rej: I see a roadmap coming afterwards. The P5 report included real projects. The Nuclear Physics long-range plan looked at the science, without picking any particular options. As I read the charge, I interpret a roadmap as coming later.
Q. Professor Terry: We are comparing ourselves to communities with a long history of community input. How are we to manage these two activities of community input and prioritization? The wave function has to collapse when we come to FESAC and generate priorities. Will this create unhappiness? At the Madison meeting, it was clear that people were learning how to have such discussions.

A. Dr. Rej: That is where we are.
A. Dr. Newman: If the first nine months are guided by the unconstrained option, and then we process a prioritization—then later on when FESAC fits it into realistic constraints, the community has already thought through it without a cutoff. That allows the best ideas to float to the top. Other ideas could be picked up in the next go-around. They community will be satisfied to have been heard and have their ideas put on a list.
A. Dr. Rej: P5 did not require the community to prioritize. NP did.
Q. Dr. Trask: Will the input be filtered? Can there be input from beyond the workshops?
A. Dr. Newman: It is completely open. The 2017 meetings were run that way.
A. Dr. Rej: DPP will provide guidance.
Statement: Dr. Newman: Last year, PPPL set up an online chat system to make comments. That allowed open community input, but not in real time. I would encourage the use of a similar tool.
Comment: Dr. Verboncoeur: There is a potential mismatch between a bottoms-up process and an architectural process.
Comment: Dr. Walker: Please include new trends, such as private fusion companies and foundations.
A. Dr. Newman: We did not include that in our top level. But, it will be included in the next-level matrix. We might go beyond the fusion industry to the energy industry. Please submit nominations.
Q. Dr. Wendt: How will the long-range planning process deal with the National Academy burning plasma report?
A. Dr. Rej: We cannot wait to get it. The release of the report is imminent. I would treat it as input, just like other input.
A. Dr. Newman: I agree from the FESAC side. From the community side, I would go back to the original input to the burning plasma panel, because that was the community part.
Q. Dr. Wirth: I have mixed feelings. I concur with needing to speak with one voice—but I am scared by the challenge. I just spent a year dealing with this (as a member of the NAS burning plasma panel). We benefited from community input. The magnetic fusion community is getting close to having one voice. Please do not walk away from the NAS burning plasma report (as David said). Did I misinterpret him? This morning, there was a comment about community fatigue—I have it. ReNeW, and even before that, had the same themes. I hope to see a reaction in DOE and on the Hill to the burning plasma report. The FESAC charge sets another two-year time horizon; but, do we have to wait that long? It would not be easy to get prioritization

among three disparate communities. Could it be done in a staged fashion, so we can put parts forward sooner?
A. Dr. Newman: I did not mean to disparage the burning plasma report work. The burning plasma report is meant less for the community, more for constituents. The community might buy into the report. But, the FES charge is portfolio-wide, so it is more difficult. The magnetic fusion part is farther along. So, there is nice synergy with the Decadal Study for the non-MFE part of the charge.

Comment: Dr. Barish: There will be an ethics briefing tomorrow at 8:00 a.m. in the small conference room in the hotel.

MEETING ADJOURNED

FRIDAY, DECEMBER 7, 2018

ETHICS BRIEFING

Dr. Barish: Please register with Sandy Newton at the registration desk if you would like to make a public comment.

FESAC Charge on Long Range Strategic Planning Activity (continued discussion from Thursday, December 6, 2018) - Dr. Don Rej, Chair
Comment: Dr. Carter: We need to embrace the work done with NAS, Madison, and Austin. How do we achieve consensus when there will be winners and losers? We cannot just say the losers will have a chance "next time." The losers have to have opportunities in the program, or a chance to participate. This is critical in how the planning process goes forward. This form of inclusion will make the program more successful. Consider that we are not fully participating in ITER yet. What is the balance of ITER vs non-ITER for increased spending?
Comment: Dr. Van Dam: Paul Dabbar wanted us to "assume we will stay in ITER" in the charge. We are not hitting the existing funding profile and the cost increase.
Q. Dr. Patello: What will the FESAC process be like?
A. Dr. Rej: This should be a part of our discussion today. It is open to everyone.
Comment: Dr. Neilson: Concerning coming up with a wish list, it is impossible for the community to prioritize if it means suggesting that certain programs should be terminated. If we concentrate on identifying growth in

the program, then we can make progress. The schedule is too tight, but maybe it is too dragged out. We need to avoid wasting time. Yesterday we heard about the decadal survey that took months to get started. FESAC needs to participate in the community activities and be ready so we can move quickly. The 2002 Snowmass worked that way.
Q. Dr. Greenfield: Jim Van Dam mentioned ITER and that contributions will continue until 2025. Should we assume ITER continues beyond 2025?
A. Mr. May: Assume that we follow the baseline ITER schedule.
Q. Dr. Terry: Can we make recommendations for our work? What will we be doing over the next year? FESAC needs to follow the community activities and formulate a list of items that we would like to see come out of the community process. This way, the community knows what can be provided to FESAC. Are we getting sufficient broad community involvement? Are all members of the community participating? This should be monitored going forward. So, when they are finished with their product, it is something that is appropriate and useful.
A. Dr. Rej: This will be essential, and we should have more frequent meetings. What do the FESAC members think?
Q. Dr. Cauble: We should communicate and get the word out to everyone in the community and remind them before acting on this. March would be a good time to hold a meeting. It is everyone's job on the committee to communicate this.
A. Dr. Rej: The advantage of the committee is that there are three ex officios.
Statement: Dr. Wirth: I support having a meeting in the spring.
Statement: Dr. Terry: The only schedule given is December 2020; FESAC has to complete its report by then. It is FESAC's responsibility to communicate to the community when we expect a report. A deadline would focus the progress.
Statement: Dr. Neilson: I also agree - the community needs to meet more often and come up with an agenda to support this.
Statement: Dr. Lumsdaine: It should be FESAC's responsibility to communicate to the community about the process when FESAC expects the community input to be handed off.
A. Dr. Newman: This is correct - the six leaders have been told to have their report ready by the January/February 2020 timeframe.
A. Dr. Rej: It is a somewhat time constrained process; it needs to be done correctly for this Administration.

Comment: Dr. Patello: The schedule is a little concerning. It doesn't give FESAC a full year. The reporting is the hardest part to get people to finish. I recommend that you get your leaders to finish by December 2019.
Comment: Dr. White: It is odd to say to do nothing for a year. Is there a possibility to form a subcommittee to interact with APS/DPP to gather information so that when the handoff occurs it can happen smoothly?
Comment: Dr. Patello: That is a good idea. We will get a written report and get more context by discussion.
Statement: Dr. Cauble: This is a good point. There is no assignment or report back process. Is March a reasonable time for Dr. Newman to report back to us?
A. Dr. Newman: This is a good time, but I am not leading this. APS/DPP is pushing the boat into the water. The seven community leaders are being selected by a subcommittee of the DPP Executive Committee, and they will lead the process. I can act as a facilitator. They should have the process in place in the January timeframe. March is a good goal to make serious progress.
Comment: Dr. Carter: I hope that FESAC does not need a year to consider this. I agree that the timeline is critical.
Q. Dr. Reyes: What is the logic behind this decision of leadership selection? Are all the elements of the committee being represented?
A. Dr. Newman: We did not have all seven of the names yet; we will hold off until we have all of the names. The process went through budget. We looked at the portfolio and divided it by the budget, then looked at representation of the leadership group. There will be gaps in coverage. The aim will be to fill the gaps in the next level down. The APS/DPP Executive Committee made the selections from 119 nominations.
Comment: Dr. Rej: This is the first step. We need to get the next level down correct. This will be announced to the community.
Comment. Dr. Greenfield: I hope that Gert Patello is being pessimistic about how much time FESAC will need, and that Troy Carter may be too optimistic that FESAC can give some of its time to the community process. Look how much preparation time there was prior to Snowmass; it will be more difficult to come to an agreement. Are there restrictions on FESAC members' participation in the community process?
Comment: Dr. Rej: The sooner the better; this would give us an opportunity for an early finish.
Comment: Dr. Lumsdaine: The group of seven is not primarily about developing and doing the work. They will be developing the process, and they are fair. The main criteria will be focusing on the effort.

Under Secretary for Science Perspective - Mr. Paul Dabbar – Under Secretary for Science

Comment: Dr. Rej: we are thrilled to have you here, and we look forward to having your perspective.

US Dabbar: Thank you for inviting me to this meeting to discuss how things are moving along on many different fronts. I will talk about the charge and how we can help the community.

I will start with an overview and a perspective of DOE and the Office of Science to set the context.

- DOE: Things are overall very positive. The core of the department is the national laboratories. That complex was there long before President Carter established DOE. There is an all-time high support across the laboratory complex in terms of budget this year. It is an interesting and unique time. There is a shift in unprecedented support for science and the national laboratories complex.
- The department has three strings with all-time high support:
    - national defense
    - applied energy
    - science
- National Defense - Decay of plutonium. This is important due to the aging of materials. DOE is still the executor of the Manhattan Project in its current form. Resources are needed for non-proliferation. There is a lot of work here. We are executing on this physics related mission.
- Office of Science - Last fiscal year, due to the support of various constituencies (some here in the room today), funding is up almost 25%. SC is not the only place for the Federal science footprint that received substantial increases. NIH is up 20%, and NSF is up 10%. Federal investment in R&D is at an all-time high. The Senate and House leadership is appreciative. They like to talk about this point. We and you need to thank them when you explain the importance of your topics. This lays the groundwork for talking about fusion.
- Applied energy offices: What's happened in the last ten years is amazing. DOE was stood up by President Carter (who went to the same undergraduate institution that I attended). I grew up in Oklahoma in the early 1970s. There were gas lines. Carter gave many sweater speeches, which can be found on YouTube. He said we would have to make do with less. Of course, efficiency is important. But, the idea of giving up on energy was wrong. The right solution was innovation. Many policies at that time discouraged innovation. In the last ten years, there has been a

dramatic improvement in innovation. The solar production all-in production costs have dropped by 99%. The wind capacity factor (wind turbine) moved 23% on short to over 50%; aerodynamic efficiencies have doubled. Oil and gas production costs have dropped by 60%. Gas turbine efficiency factors have dropped by 7500 to 6500. For battery performance, you are about to see dramatic announcements about developments that are firmly economic—thanks to investments at national labs, there are 300-500% improvements. Just yesterday, the U.S. was a net exporter of oil and gas. Last month, the U.S. was energy independent! This may become the norm. Also, last week, Excel Energy said they would go to a fully non-emitting fleet by 2050. They talk about nuclear, hydro, and renewables to hit that goal. Things are very positive in terms of energy and its production. That ties in with national security aspects. OPEC in the 1970s was related to national security. We are independent due to innovation. There is economic value to U.S. citizens. The velocity of a dollar should be 7, meaning that a dollar bounces around in the local community seven times—this is good. This is an incredibly important area. You are part of this story going forward.

- Announcements in SC: We are building user facilities—we have the capital and the footprint to do this. These facilities are cross border, open access, and merit based. They are open to anyone globally, based on merit—this is unique to the U.S. We continue to be the bright light of funding and access that is based on merit. SC has turned into one large construction zone—my favorite reference point is LBNL, which has five construction projects at the moment. BES has upgrade projects: ANL APS-U and SLAC LCLS-II. There was a quote by Pat Dehmer in FPI recently that labs should always have plans ready to go, and this is the year it happened. My last two predecessors in this job (Orr and Koonin) and I talk regularly. ASCR has commissioned the number one and number two highest-performance computers in the world, according to the 500 rankings. This is way beyond anything accomplished anywhere. There is the CBAF upgrade in NP. HEP increased its international collaboration and funding support for LBNF Dune. BER has biological and genomic projects.
- Examples of increased support: First and foremost is the science. We have Nobel Prize winners. I spent time with France Cordova at NSF. Data for four new black hole mergers were detected by LIGO, which sits at one of our DOE facilities, so we are a minor supporter, with NSF as the lead. Second, another reason is that there is a new wave of interest in innovation in the U.S. Third, there is an impact on the economy of

investment in innovation. Fourth, people care about this for international competition; we want to invest for leadership leading to jobs for Americans. Fifth and finally, SC got the biggest increase of all Federal science footprints because of the operations of the Department. User facility projects are generally on time and on budget. They are done with efficiency; we can give a positive statement.

- Specifics of FES, FESAC, and the charge: We have been very engaged with the Secretary so that he can get a perspective about the fusion program. It is hard to grab people's time who are involved with national security and with oil and gas. But, he has visited ITER, GA, and TAE Technologies. He has had conversations on the Hill with members of Congress. I have been to PPPL several times, and also MIT, GA, TAE Technologies, and the ORNL Summit supercomputer. Fusion has been a big focus for me and for the Secretary.
- Community cohesion: I sat on a DOE advisory board for 12 years. It is important to provide input about where to go, and also to foster cohesion of the community, which is very valuable and important.
- My perception about fusion: I had some experience with fusion when I was in the private sector. Now, I have gone through the SC program offices, their strengths, and how they can learn from each other. I will be direct: fusion is an important area.
- High priority focus: There is a list of high-priority items for me and SC to focus on in 2020. Quantum information science is one—we just launched the first entangled network this quarter (ANL, Fermi, and the University of Chicago); we lead the world. Microelectronics is another—for computing CPUs. Another is medical isotopes. Fusion is the only program office on my priority list for FY2020. I spend more time with FES than any other program office. Compared to some of the other program offices and their communities, this community has the most disparate views about what to invest in. I see the challenges that came about, looking at the funding profile from the Hill, which was not positive. But, now it is very positive. FES had the high end of increases for FY18 and FY19, the highest of all offices in SC. There is much interest from the Hill on this topic. Start with the increases. Now is a unique time and place for a pivot. You should grab it by the horns. Take a positive attitude from the funding, build momentum in a positive way. How is that done? I will be direct. SC has general views from stakeholders because of coherence in their communities. When they visit the Hill, they say the same things. Also the performance of their facilities is positive. Computing, BES. But, there is less of a track record in FES.

Also, there is much less coherence than HEP and BES. The FES community does not have that. Use the positive opportunity in overall sciences from stakeholders to fund science. SC is at an all-time high for interest and support. Other programs are moving with a high degree of coherence. I want your help to build on these generalities in other areas of science. How can we use that to drive coherence forward? It is a near-term opportunity. HEP had a challenge ten years ago. Secretary Chu's statement to HEP: If no coherence, no funding. So, now there is a unique opportunity. The P5 report and the NP long-range plan provide guidance for their entire communities. A year from now, on the Hill, when I am asked (and when you are asked) what we did with the 31% increase for FES, I want to whip out a card and list what everyone did. Not just Jim Van Dam or Don Rej, but the whole community. That is why we are here today. I have spent months getting ready for today's discussion.

- Science is international and this community is very much so. We enjoy collaborations. But we want U.S. leadership for each program office. We should either be number one or co-leader with every place in the world. We are with the other program areas. The U.S. should be jointly number one in user facilities and science. Anything less than that is undershooting U.S. potential. I hope you share that ambition.
- Three vectors for strategy:
    - First, existing user facilities and infrastructure—we intend to fully fund it. Funding for ITER, NSTX-U, DIII-D, and all other research infrastructure funding will continue.
    - Second, I want FES and the community to look at research infrastructure we have not funded in recent years due to budgets and strategy, things that were put on the back burner due to these challenges. The FESAC charge wants everyone's input about what we have not been investing in, but could, due to the change in the budget. Where is the place for the biggest impact of taxpayers' money? We want community input on this from a broader set.
    - Third, from my private sector and other background, I see this program as both science and also partly applied energy. DOE has some experience with applied energy. R&D across all energy sectors could be utilized. The U.S. has unique leadership in terms of private sector funding for fusion. So we should talk with labs and do typical FOAs, but also find out what we can learn from the Office of Nuclear Energy and the renewables energy offices about how to constructively engage with the world-leading private sector in funding and innovation.

These are the three pillars. Higher funding. Provide coherence. It's not a zero-sum game. Be inclusive. Show momentum, and it feeds on itself. Other SC program offices do this; I want FES also to exhibit it. I want to be able to say that everything is working perfectly.

- Key aspects:
-
- PPPL: We work closely with PPPL. I spent a lot of time at Princeton, with NSTX and the overall lab. We appreciate Director Steve Cowley's leadership and partnership, and his joining the U.S. from across the Atlantic. We cannot get you a knighthood in the U.S.! I enjoy enhanced engagement with Dr. Cowley about adding to the PPPL footprint, based on his Culham experience.
- ITER perspective: We had higher funding levels in the last two years. The ITER Organization appreciates the additional dollars. I will see DG Bigot on Monday next week. There is flexibility on how we deliver value, cash in particular.
- DIII-D: Obviously, we want to continue to deliver value.
- Research infrastructure: I was just talking with the SLAC Lab Director about ideas for MEC and how to execute those ideas.
- Public-private partnerships: The biggest example is the GAIN program in the Office of Nuclear Energy. DOE supports innovation in fission for developing new reactors. There is incremental support of the private sector. DOE does not become a commercial enterprise; we support R&D. But, we could take programs that are successful for NE and apply them to fusion. The private sector has organized itself in recent months and developed ideas how DOE can engage with them. Examples are high performance computing and opportunities for citing for new fission reactors (easier for the private sector to cite at DOE labs since the rules are easier, and they get access to resources). We might do this as we do for the NE community. We provide seed money. We provide money to universities and labs as seed funds. Others participate; universities put in money. Other research spins off from this. So, we feed a whole industry with the community putting in resources. We plan to do that in this community. There is seed money for innovation in the private sector in fusion as well.
- FESAC charge: The Secretary and I would love, in our short time in leadership positions, to help drive this community forward and use this opportunity to build coherence. The charge will provide input where to invest, but also importantly it will provide coherence in the community. The process is very important. No conflict issues. There should be

enough time so it is not rushed. We hope to get all the input we need. It will occur over 18-24 months, at the end of which, we will end up in a place where we have community input on where to invest, community agreement on where to go, where we row together in the same direction, so we can show the rest of the world that this is being done.

- I look forward to having you all drive this forward, and to your input. I welcome your questions.

Comment: Dr. Rej: A very inspiring presentation and your understanding of us, progressive ideas, and your support for the community, and your honest direct observations.
Q. Dr. Verboncoeur: Should we anticipate aggregate funding at that level?
A. US Dabbar: Funding is a balkanized process. This is normal for Federal funding. The short answer is no, I cannot guarantee funding. But, this is an opportune time for this community and everyone in science to develop plans and show what can be accomplished. If done well, an opportunity for the support exists. This is very important. This review by you and the community will have an impact on your question. The flexibility around the cash is important; support comes from strategy. When looking at funding, it is better to come up with a strategy, then ask for support to execute the strategy.
Comment: Dr. Verboncoeur: It was a rhetorical question, which you answered appropriately.
Q. Dr. Wirth: Impressive and eloquent presentation. As we go through this process, we identify where we are in each sub-element for the plan as far as international leadership.
A. US Dabbar: Correct.
Q. Dr. Verboncoeur: We must appreciate vectors: the science/energy dichotomy. Should the technology and energy investment be part of the Office of Science?
A. US Dabbar: Yes - coherence. Fusion is both discovery science and an applied energy program. No reason to say either-or. We want to support the whole community, not just one type of confinement, not just discovery or applied. We should realize that this is not a zero-sum game for those topics.
Q. Dr. Verboncoeur: Has the Administration determined to support ITER?
A.US. Dabbar: We continue to review this. The Secretary and myself and the Department are supportive, but it comes down to budget; it is being discussed.
Q. Dr. Lumsdaine: We appreciate your support and attendance. It is a statement. If decades hence, fusion is a part of the energy portfolio, will it

move from SC exclusively to an applied energy program? Currently, we are in SC, which affects how technology can be funded. How would DOE pivot to becoming more of an applied energy program?
A.US Dabbar: It is hard to describe DOE to others due to its diversity of missions. It is not binary what we do with research labs: not this or that. But, various types of research. LANL is a great example. I do not see a difference between discovery and applied; it is a continuum. Take Quantum: there is a large continuum from discovery of qubits, to turning it into sensors or networks. Not digital or analog. Right now, SC does batteries and chemistry: JCESR at ANL—that is chemistry, but 80 private companies are working at ANL on batteries. We do not see the digital nature. If FES and this area starts engaging with the private sector, while still working on materials and containment and discovery, I do not see much of a change that needs to happen.
Q. Dr. Reyes: Thank you for your presence and your work. The FESAC charge is a great way to deliver guidance in 2020. In the meantime, we have the NAS burning plasma report. A big part of FES is burning plasma. How will that report impact decisions until the FESAC report is ready?
A. US Dabbar: All reports will contain data on expert recommendations about investments. Operations of lab complexes and capital and budget allocations are two aspects of my leadership role. NAS is a wonderful group; thanks to them for participating in the burning plasma report. We will take it onboard about where we have to spend money. As I just described, we will continue to work with PPPL and NSTX, ITER, etc…; those things will continue. To execute on a recommendation from FESAC takes time; it requires work for us to get ready. The third pillar is to add incremental support with the private sector; we don't need to wait to engage. You can tell us how to do it better, but we can already start down the road.
Q. Dr. White (via Zoom): How do we leverage the private efforts in science support?
A: US Dabbar: I encourage this community if you want to see fusion as a power source, since ultimately at the end of the day it is a commodity. It makes power. There are alternatives, with similar mission scenarios. It is important for this community if you push into the energy mix, that it is not only science, but it must make economic sense. DOE funds R&D for many things: solar, wind, batteries, oil and gas, and carbon capture. Fusion needs to fit in the mix that it will sell power. I encourage everyone to think about completion of alternatives; not just science and technology—it needs to be commercial. As for engagement with the private sector, I gave a few points. As with any community we support at DOE, we have a number of user

facilities applicable across science areas, e.g. imaging. We give access to the private sector. Computing is a great value for the private sector. There is access to isotopes and algorithm development. Data about containment design with machine learning and big data, and artificial intelligence to design optimized containment, are possible; this community can use these capabilities of the Department. These are things we could help with, in addition to citing.

Q. Dr. Groebner: Thanks for coming to talk with us. There is a gap between the rank and file (like me) and DOE. We don't know what happens in Washington, how decisions are made. Your coming here shows us. Given the bickering in fusion, that we are not always coherent, why do we continue to be funded? I know why we should be funded! But what is your perspective—why you think it is worthwhile?

A. US Dabbar: Obviously, fusion works. It will bring a star to earth. The technology has reached a point where containment and other physics can actually be created in a length of time that we can learn and potentially use it. QIS is near term: quantum mechanics was identified a hundred years ago, qubit theory has been around for a long time, but only recently has there been the prospect of technology to use it for applied purposes. DOE is a big R&D sector. We are an energy department, but really we do R&D. We should invest in this area. Has fusion technology reached a point like QIS? There are things happening around the world that are possibilities. We should be at a higher risk side at DOE. We should fund it. We are the only ones who can do it at scale. However large the endowment is at Harvard, the Government has more money. We should invest in it to see if we can drive it forward. There is interesting momentum in various areas, represented by people in this room today, and something will evolve out of it, sooner than the typical 30 years.

Q. Dr. Neilson: Thank you for coming to talk with us. Concerning ITER, you and the Secretary did your homework. We are pleased that you will visit ITER. You appreciate construction projects. Your visit to ITER will excite you. Please take two data points so you can measure progress. Please meet with the staff. Will we re-establish a baseline for U.S. contributions to ITER? We had one, but now funding is a year-to-year proposition, and hence uncertain.

A. US Dabbar: Funding is embedded in your question. The challenge of the U.S. structure compared to the EU is annual budgets that will not change. Every year, there is a budget review by Congress. ITER involves both in kind and cash. The central solenoid work is being done at GA. As for the baseline, with any construction project there can be changes to the baseline.

We are engaged with DG Bigot on keeping up to speed on deliveries, cost, and cash versus in-kind support. We stay on the status of the baseline. We are trying to connect the two. I spent time in my career looking at large nuclear projects. Large civil engineering projects have challenges (fission, airports, and chemical plants—especially when they are first of a kind). There is part of me that says bigger is not necessarily better; it is more of a challenge. It behooves all of us including ITER to be on top of that. DG Bigot has done a very good job of that. Things can go awry quickly at fission projects. We support the reappointment of DG Bigot. We must stay on top of the baseline in our annual discussions.

Q. Dr. Verboncoeur: I am encouraged by discussion of innovation and economics - connecting that to cost sharing the research with private and public partnerships. No power company can capitalize a $20B reactor, so we need innovation. Cost sharing with public-private partnerships is important. Our university would have to use tuition dollars to support cost sharing. What about intellectual property (IP), since industry wants that?

A. US Dabbar: DOE has a vast machine to generate IP at the national laboratories with our own researchers. Most DOE money is at labs, although there is also the grant program. One of my jobs at DOE is as chief commercialization officer. So, I have significant dialog about IP and reaching out to the private sector, getting more value for our researchers and for the country (jobs, regional). We do cooperative agreements; if we generate IP, we own it, since our own researchers did it at our own labs. This IP is open to anyone. If someone wants to license it, we are open to negotiate it as any university would. Bucket number two is Work for Others (now called Strategic Partnership Projects). We do contract work for others to do research that others pay for in order to use it for commercial purposes. We do lots of that for the private sector. NREL in Denver has a test site for electric vehicles. The private sector of fusion is no different from how we work with Tesla, Apple, and others. So, I encourage anyone to come. We are looking at the GAIN program of the Office of Nuclear Energy. It is efficient for the private sector to pay not much money to get utilization of world-leading capabilities.

Q. Dr. Verboncoeur: I saw that at LLNL, but here we are considering a 30-year payoff, tens of trillions of dollars generated in the world economy. Maybe a new mechanism is needed to couple the private sector with the public sector.

A. US Dabbar: I agree. The challenge is having enough time at DOE—I have too much to do. A subset of the FESAC charge is to get recommendations on how to encourage private interaction.

Q. Dr. Carter: Thank you for coming. Concerning private-public partnerships, you mentioned GAIN-like activities. As we go forward to build consensus, it should be a two-way street. Are there private sector resources we should take advantage of?
A. US Dabbar: That is a great interesting idea for the group to think about. This is a great question for a subset of the charge.
Q. Dr. Ma: My field is ultra-intense lasers, related to the subject of the recent NAS report. The U.S. is falling behind. There is a brain drain to the EU. What can we do to combat that?
A. US Dabbar: The input of the community on that topic is important; please include it. Take a holistic view of where to go in discovery science, and ICF and lasers. That should be part of the charge. What can be achieved with each of the technologies should be included. Clearly, we provide lots of funding of the topic at labs and universities. We continue to fund it as we go through the budgetary processes. The bigger question is how much to fund it, and what is the output. There are defense applications too, but put those to the side. How does it fit in the stack of discovery science? We should discuss this. I want to hear from people on this. Everybody visits me and says their work is important. From my viewpoint, I think this is important. Let the process drive the answers for this and all other discovery science.
Q. Dr. Verboncoeur: I am glad you embrace discovery science. What are we not seeing that we could be doing more of?
A. US Dabbar: I have had interesting discussions recently with Steve Cowley. One topic is lithography for microelectronics and plasma science. What are the derivatives of what this community does? DOE has made incredible advances that the world cannot see. I want to increase public knowledge that the labs exist and accomplish so much. Nuclear power was invented in the national labs, including isotopes for medical purposes. The human genome started at LLNL, based on imaging capabilities for materials structure. LED lights are revolutionary and were invented at national labs. The list is vast. I was at an energy conference in Houston this year. Someone said they did a start-up company for oil and gas production optimization using gene sequencing from Berkeley. You do not know where the fractures go, so as you drill through strata, you get different micro-organism environments. They did sequencing of microbial families through the strata; then, they can figure out where the fractures go through the strata. I talked about this with Mike Wirtherell at LBNL; he said it was fascinating, and that they had never thought of that. Discovery science can have great applicability and impacts we might not realize. That is what makes it

exciting. That is why we can talk to stakeholders about impacts made and will be made, and how it will make a difference for the country.
Comment: Dr. Rej: Thanks to the members for the interesting questions, and thank you for the time you have spent with us today.
Comment: Dr. Van Dam: Thank you for your support.
Dr. Christopher Fall was introduced: I hope to be with the Office of Science very soon.
Comment: US Dabbar: Thank you for volunteering. I look forward to getting your updates.
Comment: Dr. Rej: Wow!- This is the reason why we need to do the long-range planning; and why we need to do this before Paul Dabbar leaves as Under Secretary.

BREAK

FESAC Charge on Long Range Strategic Planning Activity (continued discussion from Thursday, December 6, 2018) - Dr. Don Rej, FESAC Chair

Comment: Dr. Barish: A FESAC meeting may be held in March 2019.
Comment: Dr. Wirth: I agree on an early finish for the FESAC report. Under Secretary Dabbar is very engaged; this is very positive. We encourage the committee to think about the possibility of a staged delivery as everything comes in and do an overall prioritization at that time.
Comment: Dr. Verboncoeur: Maybe an interim report will be appropriate to get feedback. A cohesive community view is crucial, especially on the data gathering side. US Dabbar communicated innovation in process and in substance. We can expect to see increased resources following that success.
Comment: Dr. Lumsdaine: Strategic planning always starts with vision, values, and mission. If it purely starts from below, it is hard to do. The plan should not be a list of what to do, but how to get where we want to go, which involves values and mission.
Comment: Dr. Greenfield: I will beat a dead horse again. There is a mismatch. We have an opportunity with a sympathetic set of political leaders who are excited to help us, and a process to produce a report shortly after the next presidential election. Maybe we cannot do anything about this. We cannot change the charge. But, can we do something faster? Maybe the answer will be in the NAS Burning Plasma report.
Comment: Dr. Rej: An interim report will be a great opportunity and provide FES leadership to give the latest updates.

Q. Dr. Groebner: What does strategic planning mean? US Dabbar discussed this. What is the path forward?
A. Dr. Newman: From the point of view of the community process, it has to be decided by the community; what does FESAC want as an input to their process? What FESAC wants as input needs to be synchronized with the community input.
Q. Dr. Knowlton: Do you envision the overseers to shape how the town meeting leaders have been selected; what are best practices?
A. Dr. Newman - This is up to FESAC. The seven overseers will help with hand off to the next generation since they will put in a lot of work over the next year.
Q. Dr. Patello: Let me ask about the handoff and what information to provide. Will FESAC develop guidance for this handoff? It depends on the community responding to the seven bullets in the charge and taking into account budget scenarios. Also, could we get quarterly updates, even in a virtual meeting of FESAC?
A. Dr. Rej: These are good ideas. The updates will continue. The updates to FESAC will be open to the public; FESAC meetings will be announced in the Federal Register. What should we do to make sure the communication is there and the process is moving forward? We hope to have a March meeting where Mike Maul can give a presentation on the NAS burning plasma report.
Comment: Professor. Pedersen: After hearing US Dabbar, this is a golden opportunity. We should speed up the process, even if the charge tells us not to. We should be creative on how we observe the charge. We should be involved without going beyond what it says. I fear that we might dictate the content; we should not do that. Cohesion and consensus are most important. It is not that FESAC does nothing for a year. We need to get going earlier. This will require much of our time. I like Gert Patello's idea of virtual meetings; they can be more frequent. We should be more involved early on. We should interpret the charge proactively.
Comment: Dr. Newman: The subpanel shouldn't be empaneled early, according to the charge.
Comment: Dr. Rej: I agree.
Comment: Dr. Cauble: FESAC should not run the community activity. The impedance match would be better if the FESAC subcommittee is appointed early, but instead we on FESAC should be involved in the community activity.
Q. Dr. Trask: Concerning vision and values to request from the community, who will write those, and when will they be circulated?

A. Dr. Newman: The community has to do that.
Q. Dr. Trask: I meant input from FESAC about what type of things to be considered. Someone should take the lead on writing and circulating it for our perusal.
A. Dr. Rej: Before the March meeting.
Comment: Professor Terry: There was the idea whether FESAC should form a subcommittee, but the charge gives us no wiggle room to do that. So, we will attend meetings. Don Rej might make assignments without forming a subcommittee.
Q. Dr. Patello: I have been involved in strategic planning processes. That has often been the starting point. Vision and mission for what? Of FES, or for the outcome of the planning process? I am not sure that FES is open to having its mission changed.
A. Dr. Rej: FES has its ten-year perspective. Our role in a ten-year plan would support that perspective overall and adjust as new ideas come in.
Comment: Dr. Patello: So, mission and vision are already drafted from FES. If the community articulates values, that will help with the prioritization process.
Q. Dr. Greenfield: Let me ask about FESAC members participating in the community process. Sam Barish pointed out our limitations on this. We need guidance on this soon.
Q. Dr. Lumsdaine: Perhaps many of us do not know the mission and vision. Should these be publicized?
A. Dr. Rej: It is on the FES web page.
A. Dr. Newman: I will make the community aware of them.
Comment: Dr. Walker: An incoherent community and factions were mentioned. FESAC should identify the reasons, so the next plan does not have trouble with this.
Q. Dr. Demers: The list of bullets in the charge has nothing about continuing leadership or challenging decisions about where to cede leadership. Also, there is nothing about rolling off projects. Under a constant level of effort, that might have to happen. The charge does not mention maintaining and/or upgrading projects; it only uses those verbs for facilities.
A. Dr. Rej: The word “pivot” might include that.
A. Dr. Van Dam: Feel free to use all three verbs for projects as well as for facilities. We used the word pivot deliberately to mean many things. We did not explicitly include the option or need to shut things down, since that can cause conflict of interest issues (see the Rosner FESAC panel report). Also, the P5 and NP charges did not include this explicitly.

Comment: Dr. Demers: People will take the bullets literally. This needs articulation.
Comment: Dr. Van Dam: Feel free to articulate what I just said.
Comment: Dr. Newman: We need to develop a plan. Do not get lost in the weeds or the verbs.
Q. Dr. Verboncoeur: The Under Secretary talked about innovation. He even said things are on the table for process. Maybe ARPA-E style. Should FES think about that and translate it, but on an appropriate time scale? We have not yet seen the seven pillars. Please circulate those without the areas.
A. Dr. Newman: There are seven leadership areas. Three nominally from MFE, one from basic plasma, one from HEDLP, one from alternates, and one from materials and technology.
Q. Dr. Verboncoeur: What about emerging technologies and processes?
A. Dr. Newman: Of course, there are other areas, getting farther down. Hopefully, all seven will encourage lower layers to keep that in mind.
Comment: Dr. Rej: I agree with David Newman. These seven will be the enablers.

PUBLIC COMMENTS:

Richard Buttery (General Atomics): Speaking in a personal capacity, not on behalf of GA. Concerning strategic planning, there is compartmentalization in the program. Different programs work in isolation. This leads to winners and losers. We should foster collaborator and ring-fencing. An example is with universities. We did discovery science on DIII-D. University researchers want the same thing we do. We need to come to grips with the same questions with reconnection in the Sun and the magnetosphere. But, discovery science is not allowed to argue relevance to fusion. We should remove this limitation. Universities can use tailored facilities of relevance to major facilities. DIII-D is testing helicon current drive on LAPD. Also, there are commonalities and synergies between DIII-D and NSTX-U, and elsewhere. We should pool our expertise. We get a stronger program if we bring expertise to whatever facility or program. Suggested actions: Enable crosscutting collaboration; remove barriers. Have more national initiatives and national teams. Help alignment. Avoid winners and losers. Lever skills for a more effective program.
Comment: Dr. Rej: Thank you.

Michael Zarnstorff (PPPL): We are very thrilled by the support of Under Secretary Dabbar. We take this as a galvanization of these activities; a great statement of support. The importance of building coherence and strategy and confidence to build this together. US Dabbar is asking us to re-invigorate this program and re-engage in the international community. This will engage younger people; a generational opportunity. This will be a dominating activity for the next few years. It will take real work to work together across institutions. We need to have discovery, investment, and a persistent strategy. It is important to work together with private companies that bring other perspectives and resources, and focus on practical applications, different from academic research. They leverage and are impactful. In putting in the time and the energy, we can be successful. We need to plan the process carefully, since consensus is not easy. We went through this two decades ago, and we lost it. We must regain and not lose it going forward. We at PPPL are looking forward to contributing to this.

Matthew Miller (President of the Stellarator Energy Foundation): We are a 501.3C private charity. We want to be the "third p" (philanthropy in addition to private and public). We encourage accelerating the economic deployment of fusion on the grid to make an environmental difference. Members of the panel should reflect that goal. The fusion community has made an enormous impact.

Comment: Dr. Van Dam - Thank you. This has been a great meeting. I am very invigorated by this. At another Federal advisory committee meeting, Under Secretary Dabbar had no questions and no applause. You were all very engaged, and we appreciate that.

THANK YOU! The meeting was adjourned at 11:58 a.m.

Certified as Correct by:

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Dr. Donald J. Rej, FESAC Chair
Date
May 29, 2019