

FUSION ENERGY SCIENCES ADVISORY COMMITTEE
to the
U.S. DEPARTMENT OF ENERGY

PUBLIC MEETING MINUTES

Hybrid Meeting

April 30, 2024

**Fusion Energy Sciences Advisory Committee Meeting
April 30, 2024**

The U.S. Department of Energy (DOE) Fusion Energy Sciences Advisory Committee (FESAC) convened on Tuesday, April 30, 2024 at the Rockville Hilton in Rockville, Maryland, for a hybrid in-person/Zoom meeting from 10:00 a.m. - 4:38 p.m. Eastern Time. The meeting was open to the public and conducted in accordance with the requirements of the Federal Advisory Committee Act (FACA). Information about FESAC and this meeting can be found at <https://science.osti.gov/fes/fesac>.

Committee Members Present

Dr. Anne White (Chair), Massachusetts Institute of Technology (MIT)	Dr. Edward Lahoda, Westinghouse Electric Company
Dr. Dereje Agonafer, University of Texas at Arlington	Dr. Tammy Ma, Lawrence Livermore National Laboratory (LLNL)
Dr. Emily Belli, General Atomics	Dr. Richard Magee, TAE Technologies
Dr. Luis Chacon, Los Alamos National Laboratory (LANL)	Dr. Lorin Matthews, Baylor University
Dr. Luis Delgado-Aparicio, Princeton Plasma Physics Laboratory (PPPL)	Dr. Carlos Paz-Soldan, Columbia University
Dr. Franklin Dollar, University of California Irvine	Dr. Susana Reyes, Excimer Energy
Dr. Ane Lasa Esquisabel, University of Tennessee	Dr. Erica Salazar, Commonwealth Fusion Systems
Dr. Brenda Garcia-Diaz, Savannah River National Laboratory (SRNL)	Dr. David Senor, Pacific Northwest National Laboratory (PNNL)
Dr. Beth Guiton, University of Kentucky	Dr. Andrew Sowder, Electric Power Research Institute (EPRI)
Dr. Stephanie Hansen, Sandia National Laboratories (SNL)	Dr. Bhuvana Srinivasan, University of Washington
Dr. Paul Humrickhouse, Idaho National Laboratory (INL)	Dr. Derek Sutherland, Zap Energy
Dr. Eva Kostadinova, Auburn University	Dr. Mitchell Walker, Georgia Institute of Technology
Dr. Carolyn Kuranz, University of Michigan	Dr. Howard Wilson, Oak Ridge National Laboratory (ORNL)

Committee Members Absent

Dr. Ralph Izzo, Public Service Enterprise Group, Inc. (PSEG)

Ex Officio Members Present

Dr. Lauren Garrison, American Nuclear Society (ANS), Commonwealth Fusion Systems

Dr. Edward Thomas, American Physical Society, Division of Plasma Physics, Auburn University

DOE Personnel Present:

Dr. Jean Paul Allain, Associate Director of Science for Fusion Energy Sciences (FES)

Dr. Sam Barish, FESAC Manager

Dr. John Verboncoeur, Institute of Electrical and Electronics Engineers, Nuclear and Plasma Sciences Society (IEEE NPSS), Michigan State University (MSU)

Dr. Harriet Kung, Acting Director for the Office of Science (SC) and Deputy Director for Science Programs

Approximately 250 individuals were present in person or online for all or part of the meeting.

Tuesday, April 30, 2024

Welcome and Opening Remarks, Dr. Anne White, Chair, MIT

Dr. White convened the meeting at 10:01 am and expressed appreciation for the presence and efforts of the fusion and plasma sciences community. The meeting will contain presentations from two current charges: The Facilities Construction Projects (FCP) and, the FES Decadal Plan (DP). The committee's acceptance of the draft FCP report will be decided by an afternoon vote.

Under Secretary for Science and Innovation Perspective, Dr. Geraldine Richmond, Under Secretary for Science and Innovation

Dr. Richmond shared prerecorded remarks and highlighted FES's recent successes. Highlights include strengthening international partnerships through ongoing leadership at the International Thermonuclear Experimental Reactor (ITER) and recent research and development (R&D) agreements with the United Kingdom (U.K.) and Japan. All efforts are guided by the Biden Administration's Bold Decadal Vision (BDV) for commercial fusion energy. A new division, named Enabling Science and Partnerships, was formed in FES.

Appreciation was expressed for FESAC's efforts with both the FCP and the DP charges, the leadership of the departing Director of SC, Dr. Asmeret Berhe, and the current Acting Director Kung.

Office of Science Overview and Update, Dr. Harriet Kung, Acting Director, SC

Dr. Kung expressed appreciation to FESAC members for their dedication to the community and efforts supporting SC. Appreciation was expressed for Dr. Berhe's contributions to SC, and notable programmatic accomplishments were reviewed.

The creation of the new Enabling Science and Partnerships (ESP) division, and the Accelerator and Technology (AT) division, which will include Accelerator Research and Development and Production (ARDAP), was announced for the FES and High Energy Physics (HEP) programs, respectively.

The mission of SC was summarized into three pillars: Driving Discovery Science for the Nation; Fostering Great Minds and Great Ideas; and Providing Unique, World-Class Facilities. Highlighting a focus on SC communication efforts, a graphic of numerical statistics of SC stewardships was shared. Statistics included: six core science programs; ten DOE national laboratories; three supercomputers; 11,100 permanent Ph.D.'s, 3,400 postdoctoral associates, 5,200 graduate students, and 9,700 other personnel; 39,500 users at 28 facilities; four bioenergy research centers; two energy innovation hubs; 51 Energy Frontier Research Centers (EFRCs); and 23 million square feet of space, across 1,600 buildings, on 38,000 acres of land.

The Fiscal Year 2024 (FY24) Enacted Budget reflects strong support for SC among the Biden Administration, Congress and the scientific community. Notable points include: a budget of \$8.24B, representing an increase of \$140M over FY23; \$30M to initiate Microelectronics Science Research Centers; \$45M to initiate Fusion Innovation Research Engine (FIRE) Collaboratives; a reduction of the Energy Earthshots Initiative to \$20M; support for user facilities at 89% operations; and direction from the Congress to fully fund research awards up to \$2.5M, up from a previous cap of \$1M. FY24 funding opportunity announcements (FOAs) include the Funding for Accelerated, Inclusive Research (FAIR) and Reaching a New Energy

Sciences Workforce (RENEW) initiatives.

The FY25 budget request totals ~\$8.6B. Highlights include: \$259M for AI research, an increase of \$93.1M from FY24; \$94.7M for microelectronics, an increase of \$22M, which includes \$45M for Microelectronics Science Research Centers (MSRCs); a \$18.8M increase for U.S. fusion acceleration, which includes the FIRE collaboratives; \$20M for research on climate change and clean energy; \$115M for SC Energy Earthshots, representing a \$95M increase; \$120M for RENEW, a \$68.6M increase; and \$64M for FAIR, an increase of \$31.6M. Roughly \$190M is allocated for scientific facilities, \$50M for upgrading core laboratory infrastructure, an increase of \$31.7M; and \$5M for the Laboratory Operations Apprentice Program, an increase of \$2M. The PPPL apprenticeship program for training skilled technicians was highlighted as a model for future training at other national laboratories. \$259M was requested for artificial intelligence and machine learning (AI/ML), representing an increase of \$93.1M. The Frontiers in Artificial Intelligence for Science, Security, and Technology (FASST) initiative was highlighted as a mechanism to both recognize the value and mitigate the threats posed by AI/ML. The five areas of focus for AI/ML are: AI for Science, including Scientific AI Foundation Models; AI Hardware Innovation; AI for User Facilities and Advanced Instrumentation/Technology; AI Tools for Design and Evaluation of Trustworthy AI Systems; and a diverse AI workforce.

FESAC's efforts on the Long-Range Plan (LRP) and FCP were applauded, and the LRP science and technology drivers were mentioned. The 2003 publication "Facilities for the Future of Science: A Twenty-Year Outlook" was highlighted, in which previous Director of SC Dr. Ray Orbach ranked ITER as having the highest priority among future major facilities across DOE disciplines. The publication has driven 20 years of investment in U.S. scientific excellence, including the Linac Coherent Light Source (LCLS), the Facility for Rare Isotope Beams (FRIB); Leadership Computing; the Continuous Electron Beam Accelerator Facility; and the National Synchrotron Light Source II (NSLS-II).

Vision for the Fusion Energy Sciences Program, Dr. Jean Paul Allain, Associate Director, FES

Dr. Allain shared the key elements of the vision for FES: Workforce Development and Sustainment – FES must serve as inspiration and role models for supporting the career paths of the future workforce; Bridging Gaps – converging private and public sector priorities; and Transformational Science – understanding that foundational science is a core component of U.S. competitiveness and moves technology from the laboratory bench to societal applications. The U.S. fusion energy ecosystem has positive impact on economic development, perceptions of science and problem solving.

Major challenges are posed by the many technologies at low Technology Readiness Levels (TRLs), highlighted as technology gaps in the LRP. Strategies to leverage all available resources are required to achieve an FPP. The three competing approaches for a fusion power plant are magnetic confinement fusion (MCF), magneto-inertial fusion (MIF) and inertial fusion energy (IFE), all of which require maturation to bolster private sector participation.

The FY24 budget included a significant sum of \$790M, which includes funding for several FOAs: Collaborative Research in Magnetic Fusion Energy Sciences on Long-Pulse International Stellarator Facilities – leveraging international collaborations; High Energy Density Laboratory Plasma Science; Opportunities in Foundational Fusion Materials, Nuclear Science,

and Technology; FAIR and RENEW – providing a bridge to communities previously unengaged in fusion energy science; and FIRE collaboratives. The FIRE collaboratives provide bridges to the private sector, which emphasizes the LRP’s focus on science drivers and TRLs. The collaboratives are designed to coordinate and connect with user-defined and inspired research, including the needs of fusion developers.

Efforts in FES are focusing on alignment with the LRP and BDV. Restructuring the budget to ensure investments reflect the community results in five buckets of opportunity: Theory and Simulation; Fusion Materials and Internal Components; Emergent Plasma Concepts; Closing the Fusion Cycle; and Discovery Plasma Science and Technology. Buckets contain cross-threads which involve national facilities and capture public-private partnerships. The Fusion Workforce Pathways program was highlighted as having great potential for building bridges with universities and other entities.

Enabling Science and Partnerships is a new and third division of FES, providing distinction from the foundational research focus of the Research Division. The new division is a part of current budgeting and operational strategies and a precursor to synergies with other programs. Additional details of the FES front office were shared including staffing changes, and transitions in preparation for work outlined by current FESAC charges. FES alignment and re-structure involve: Strategic inputs from the community; Re-alignment and budget restructure; and Impact Drivers, including the Fusion Science and Technology (FS&T) Roadmap, with an estimated completion date of calendar year 2025 quarter 1 (CY25 Q1).

A call for nominations for the 2025 E.O. Lawrence Awards was announced for early- to mid-career scientists. An FES Office Hours workshop program was announced, which takes place the first Wednesday of each month from 2:00 – 3:00 pm Eastern Time, and is run by program managers who will also be available to answer questions. FES is engaging “outside the sandbox” to leverage funding, including a presentation of fusion energy as a use-case for the DOE Foundation for Energy Security and Innovation (FESI), and participation at the Climate Impact Summit 2024 in London. Fusion Energy Week occurs May 6-10, 2024, and includes over 30 events, such as a Capitol Hill briefing, meetings and tours.

Discussion

Dr. Kostadinova appreciated Dr. Allain’s attention to workforce development, noted that the last two BESAC reports were published in 2004 and 2014, and asked if SC or FES would produce another workforce report in the near future. **Dr. Allain** confirmed that a report was coming soon. Workforce pathways also required engagement with educators and bridging the gaps within engineering and science.

Dr. Paz-Soldan expressed anticipation for FIRE collaboratives, asked for updates, and asked where relevant information could be found. **Dr. Allain** explained that an FOA is coming soon, pending completion of the approval process. FOAs involving the collaboratives are complex, as university and national laboratory leadership, as well as engagement with industry, are involved.

Dr. Humrickhouse recalled that input for the FS&T roadmap was being solicited from the community and asked whether the CY25 Q1 date mentioned in Dr. Allain’s presentation was the anticipated completion date. **Dr. Allain** clarified that a significant amount of input has already been gathered, and care is being taken to avoid the replication of labor. The community

workshops will serve to distill information. The process is meant to be a dialogue, and the completion date is not definite, to ensure all relevant voices are heard.

Dr. Verboncoeur mentioned the difficulty in hiring metallurgists due to the lack of funding streams, suggested that FES seek partnerships to maintain required competencies, and include discussions of efforts related to competencies in reports. Another suggestion was a clearinghouse for positions involving a national internship program partnering with private organizations in fusion. FES could then track the rate of intern absorption and whether the level of interns funded matches the requirements in the field. **Dr. Allain** agreed and explained that proactive engagements with the private sector, international partnerships, and internships are all part of the vision, and a strategic focus on competencies should be possible.

Dr. Agonafer explained the difficulty of adding new fusion courses in the university curriculum, and suggested the insertion of relevant modules, webinars and lectures into existing courses. In addition, keynote addresses at fusion energy conferences would increase interest in the field. **Dr. Allain** agreed and divulged the recent deliverance of a keynote presentation at the New Jersey AI Summit. Fusion is not just a solution to climate change but an aspect for economic impact and could incorporate AI as an enabling tool.

Dr. Salazar agreed with the importance of closing gaps between engineering, physics and fundamental science, and asked how the needs of the workforce could be gauged. In addition, professional engineering societies should be considered as a source of diversity, equity, and inclusion (DEI) and workforce development. **Dr. Allain** agreed and recalled the personal development of being a chapter president for the Society of Hispanic Professional Engineers (SHPE). FES would benefit from improved leveraging of interactions with professional and technical societies.

Dr. Delgado-Aparicio asked whether international partnerships would be considered for the FIRE collaboratives. **Dr. Allain** explained that the current focus is on the upcoming FOA, and the possibility of having international partnerships with FIRE collaboratives is not yet known. However, strategic partnerships between FES and other nations already exist, and the FIRE collaboratives could be an opportunity for additional partnerships.

Dr. Sutherland asked how private fusion companies could contribute to DOE during its current period of transition. **Dr. Allain** explained that the best contributions would be numerous, open, and courageous dialogues, which put the needs of fusion energy above individual interests.

Dr. Verboncoeur suggested that DOE and FES employ AI to reduce the manual labor of digesting accrued program materials and inputs, and develop priorities. **Dr. Allain** agreed.

Draft Report of the FESAC Facilities Construction Projects Subcommittee, Dr. Brian Wirth, Subcommittee Chair, University of Tennessee, and Dr. Carlos Paz-Soldan, Subcommittee Vice Chair, Columbia University

Dr. Wirth reviewed the FCP charge, and announced that the short letter report contains a strong consensus opinion on four facilities which best serve the community. Question 2a. of the charge requires the evaluation of facilities according to potential to contribute to world-leading science in the next decade. The Subcommittee chose to broaden the content of Question 2a to “potential to contribute to world-leading science **and/or close fusion technology gaps**”. The decision was approved by Dr. Allain, the DFO, and FES Associate Director. Question 2b. of the

charge requires evaluation of the facilities by readiness for construction.

Dr. Paz-Soldan discussed the subcommittee's process in responding to the charge. The subcommittee was informed by prior reports, including LRP, NASEM21, and BDV. Recent events were also acknowledged as influential to the subcommittee, including demonstrations of scientific gain from NIF in the U.S., 69 megajoules (MJ) of fusion heating for over 6 seconds in the U.K., milestone-based public-private partnerships, and the BRN workshop on IFE. The subcommittee's call for white papers resulted in 40 papers from the community, which discussed the facilities provided in the FES list, and proposed additional facilities.

Twelve facilities were considered, including ten provided by SC-1 to FESAC and two added by the community. The facilities were: the Blanket Component Test Facility (BCTF); the DIII-D Exhaust and Confinement Integration Tokamak Experiment (EXCITE) Upgrade; the Fuel Cycle Test Facility (FCTF); the Fusion Integration Research and Science Test Facility (FIRST); the Fusion Prototypic Neutron Source (FPNS); the High Heat Flux Facility (HHF); ITER; the Matter in Extreme Conditions Petawatt Laser Upgrade (MEC-U); the National Spherical Torus Experiment-Upgrade Liquid Metal Core Edge facility (NSTX-U LMCE); the Midscale Stellarator; EXCITE options; and new IFE concepts and upgrades.

Dr. Wirth explained when present, only upgrades or new facilities were evaluated, as specified by the FCP charge.

Dr. Paz-Soldan detailed the role of webinars in the process: one webinar per facility was held and advertised to the community; speakers were selected based on white paper submissions; webinars included a community overview, with consensus elements whenever feasible; and question and answer (Q&A) sessions were done in public.

Criteria for selection included: urgency of timeline with decadal impact on fusion industry/science; alignment with LRP and BDV; response to charge questions 2a/2b; opportunities for partnerships; and the facility's potential of closing technology gaps and/or contributing to world-leading fusion science. The facilities chosen as "absolutely central" in response to question 2a were (in alphabetical order): BCTF, FCTF, FPNS, and ITER. Each of the four facilities listed support multiple pathways to fusion energy. The other eight facilities were all deemed "important" in response to question 2a, although many were associated with single-concept fusion confinement approaches. All twelve facilities varied considerably in readiness for construction.

Dr. Paz-Soldan discussed modalities to leverage partnerships, which could elevate facility readiness for construction and share costs. Partnerships could include: other agencies such as the National Nuclear Security Administration (NNSA), the DOE Basic Energy Sciences program, or the National Science Foundation (NSF) for mission-adjacent work; public-private partnerships for concept-specific facilities; or international partnerships where strategically relevant. Closing the Integrated Tokamak Exhaust and Performance (ITEP) gap is a concept highlighted in the LRP as necessary for FPP readiness, and facilities working towards closing the gap were ranked as important.

For question 2a, the DIII-D upgrade, EXCITE options, FIRST, HHF, the new IFE concepts and upgrades, MEC-U, NSTX-U LMCE, and the Midscale Stellarator were all evaluated as "important."

Question 2b addressed construction readiness; ITER, the DIII-D upgrade, HHF, and

MEC-U are all seen as ready to initiate construction. The non-nuclear BCTF option with trace tritium, FCTF, FPNS, EXCITE options, NSTX-U LMCE, and the Midscale Stellarator were considered to have significant scientific or engineering challenges before initiating construction. The following facilities need either their mission or technical requirements more fully defined: the nuclear BCTF options, FIRST, and new IFE concepts and upgrades.

In summary, all 12 facilities evaluated were deemed at the least important to fusion energy sciences. The subcommittee found the top four to be BCTF, FCTF, FPNS, and ITER, all of which support multiple pathways to fusion energy. No further attempt to prioritize or rank the facilities was performed. Appreciation was expressed for the community's rapid response and participation.

Dr. White dismissed the meeting at 12:22 p.m. for lunch and **Dr. Walker** reconvened the meeting at 1:01 p.m.

Discussion of the Draft Report on Facilities Construction Projects, Dr. Mitchell Walker, Interim Chair

Dr. Walker led the committee through comment, question and answer, and amendment proposal sessions. Due to conflicts of interest (COIs), the DOE Office of General Counsel determined that the following FESAC members should be recused from voting on and discussing the FCP report: Dr. Belli, Dr. Delgado-Aparicio, Dr. Dollar, Dr. Garcia-Diaz, Dr. Humrickhouse, and Dr. White. Dr. Walker will serve as the interim FESAC chair during the FCP report discussion.

Dr. Kuranz expressed concern about the report's adherence to the charge, questioned if the expansion of question 2a placed more emphasis on closing technology gaps than contributing to world-leading science, and asked if the subcommittee would produce separate scores for closing gaps and contributing to science. The only facility tied to the LRP's science aspect was MEC-U, and this facility was not chosen as best-serving. In addition, several slides mention contributions to world-leading "status" instead of "science." Finally, the upper limit for ITER's costs is excluded, and there is uncertainty in the timeline for the knowledge transfer's alignment with the roadmap. **Dr. Wirth** explained that the word "status" instead of "science" was due to a typo. Also, FES chose the facilities to be evaluated, not the subcommittee. The \$100M stipulation posed in the charge prevented the consideration of many science facilities. The subcommittee aimed to balance science and fusion technology. The exclusion of MEC-U from the best-serving list is based on community guidance on IFE, and the facility's inability to conduct implosions and ignitions. **Dr. Paz-Soldan** explained that facility costs listed were given to the subcommittee, and the verification of costs is outside of the charge's scope. The alignment of timelines is an active effort. Finally, producing separate scores related to technology gaps and science is beyond the charge's scope. **Dr. Allain** noted that the number listed for ITER is the total cost, not a range and explained that the report is just one of several inputs which will inform investment decisions.

Dr. Magee noted that opportunities to leverage international partnerships were missed in several facility discussions, such as the International Fusion Materials Irradiation Facility (IFMIF) for FPNS. The need for a dedicated domestic facility providing redundant capabilities available abroad requires justification. In addition, the DIII-D upgrade was cast as EXCITE, yet

the presentation was unclear whether the DIII-D upgrade is meant to address the EXCITE goal. Finally, as the FESAC FCP report will be combined with reports from other SC programs, consideration must be given to the level of down-selection possible for fusion facilities.

Dr. Lahoda expressed a general disagreement with all the facilities described in the FCP report. Once established, big facilities require constant feeding and funds. A small, single-use facility should be built to solve specific problems at lower costs. Clarification on the committee's vote on the report was requested. **Dr. Mitchell** explained that the vote is for acceptance of the report, which will be revised to include all amendments agreed upon by the committee. **Dr. Paz-Soldan** reemphasized that the subcommittee was tasked with evaluating a list of facilities provided by SC. Determining facility type or location was outside the charge's scope. **Dr. Allain** added that facility type, location and scale are important considerations and are taken into account by SC.

An amendment was proposed by Dr. Lahoda for all data acquired for the implementation of an FPP be industry driven, and only implemented after consideration of total costs. **Dr. Barish** objected, and explained that the comment does not pertain to the charge. **Dr. Allain** added that the comment is well taken for the process but unrelated to the charge's scope.

Dr. Matthews said that the BCTF was ranked as having high importance, despite remarks of the U.S. not being a part of the ITER test blanket module, and should be leveraged as an international partnership.

Dr. Reyes noted the subcommittee's composition being dominated by magnetic fusion energy (MFE) community members. Subsequent subcommittees should be balanced with IFE community members. Clarification is needed on the process of consolidating the FCP reports from each SC program. Of the facilities ranked best-serving, only ITER is ranked with two (a)'s for questions 2a and 2b, while the other three have ranks of (b) or (c) for readiness. ITER's timeline and scope are concerning and require additional discussion. More granularity in the ranking system is needed as facilities at the pre-critical decision CD-0 level were ranked as (a) ready to initiate construction, which is unfair to facilities at the post CD-1 level. Finally, clarification is needed on whether FIRST could be an alternative to the facilities identified. **Dr. Wirth** explained that the charge designated three categories for construction readiness. Public programs following DOE order 413.3b, cannot rank facilities at the \$100M scale, and pre-CD-0 level, as ready to initiate construction. However, HHF received an (a) ready to initiate construction ranking because it is not subject to the 413.3b process. **Dr. Paz-Soldan** explained that all four facilities identified as best-serving are crucial to the field, but only ITER had justification for two (a) rankings. However, the identification of BCTF, FCTF, and FPNS as best-serving will serve to accelerate facility development. **Dr. Allain** explained that FIRST is closest to FPNS in regard to how the community evaluates a facility, but could be considered in parallel. Input for down-selection includes the FCP and LRP reports, the BDV and many other sources. All inputs will be used to make a roadmap which prioritizes investments.

Dr. Ma stated that the IFE section should note that high energy and high-power lasers are important.

Dr. Wilson commented that selection based on pathways to fusion may undermine viable pathways for the BDV and a future FPP. Clarification is needed on how the views of private companies were inferred. **Dr. Paz-Soldan** explained that views were collected through white

papers and webinars. Members should alert the subcommittee if views of the private sector have been misrepresented. **Dr. Salazar** reiterated that opinions were also collected through Q&A sessions.

Dr. Verboncoeur said that supply chain limitations must be considered on equipment and skilled labor. State-wide coordination may be necessary to ensure timely project completion. A table would help communicate the multipurpose nature of the facilities under discussion. In addition, operation costs of the respective facilities must be considered to maximize investment value.

Dr. Sowder stated that it was unclear how the challenge of transitioning from basic science to engineering and applied science will fit into the BDV. In addition, the report's high ranking of ITER is concerning given the construction timeline, and conditions for its continued endorsement should be discussed. Finally, the report is a snapshot in time, and clarification is needed on how conclusions will fit into a changing landscape. **Dr. Allain** explained that the changing landscape is a risk for both public and private sectors. Not all efforts will succeed, but strategic investments and proactivity are key for mitigating risks. **Dr. Salazar** added that the report noted rapid development around IFE, and reassessment of the report will be warranted as the landscape changes.

Dr. Guiton explained that regarding the BCTF, it would be helpful to know whether FES will be involved with the ITER test blanket module program. Also, some cost ranges span an order of magnitude, and final costs affect readiness levels, and factors affecting costs should be considered. Finally, the FPNS was the only facility listed as crucial for an FPP, and it is unclear whether the subcommittee intended, or was permitted to establish, this level of prioritization. **Dr. Wirth** reiterated the report's language: the exclusion of FPNS will pose risks to some fusion concepts, and not make them unattainable. An FPP can be built with today's materials if it involves reduced-activation ferritic-martensitic (RAFM) steels at a temperature between 400-450 degrees Celsius. Using materials outside that window without FPNS will involve high risks.

Dr. Agonafer commended ITER's role in knowledge transfer and student internships. AI is a disruptive technology and may aid in facility construction.

Dr. Hansen expressed concern over the facility rankings prioritizing closing technological gaps and engineering over addressing fundamental scientific contributions. Fundamental challenges remain in light source and target physics that go beyond the engineering challenges addressed by the facility recommendations.

An amendment was proposed by Dr. Hansen to include either a chart level assessment of each facility's potential for scientific impact, or some other method that highlights the balance between technology and science. **Dr. Wirth** objected, and explained performing individual evaluations for closing technology gaps and scientific contributions is outside the charge's scope. The report jointly addresses scientific contributions and technology. **Dr. Paz-Soldan** also objected and reiterated that a concerted effort was made to highlight scientific merit in the report. The balance between technology and science could be mentioned in the front of the report. **Dr. Allain** added that SC is aware of both the scientific and technological contributions of each facility.

Dr. Esquisabel explained that because the U.S. is not part of the ITER test blanket module (TBM) program, it was appropriate to rank BCTF among the best-serving facilities. The

report should be more explicit for the exclusion of international facilities. IFMIF will not be available until the 2030s, which is beyond the BDV timeline, and concerns exist over the shipping of tritium and activated materials.

Dr. Esquisabel's proposed amendments include clarification on the feasibility of facility partnerships. **Dr. Paz-Soldan** agreed that the front of the report could explain that the opportunity for partnerships is not an obligation for the department. and designation of question 2a, the facility's potential for impact, as holding more weight than question 2b, readiness for construction. **Dr. Paz-Soldan** agreed, that the front of the report could describe how the criteria were weighted. **Dr. Wirth** objected; the facilities were chosen with equal consideration for questions 2a and 2b.

Dr. Senor disagreed over the inclusion of ITER among the best-serving facilities, but the related experience, licensing and supply chain management are valuable. While the report mentions collaborations with some United Kingdom Atomic Energy Authority (UKAEA) facilities, it excludes the Liberty project, which is a possible course of synergy.

Dr. Chacon said that addressing technology gaps is required for an FPP; facility readiness should be addressed further in the report.

Dr. Allain emphasized that the spectrum of opinions and ideologies expressed is not uncommon for a science and technology community on the verge of transition from fundamental to enabling science. Granularity will increase in subsequent steps of the process. Regarding concerns of down-selection, balancing fusion technology and science is a high priority for FES. **Dr. Kuranz** accepted that a spectrum of ideologies will persist, but noted that the charge specifically mentions science.

Dr. Garrison commented that a graph or table to highlight facilities, rankings and concepts would be helpful; More details on the content and processing of the 40 white papers received is needed. Page six of the report used the term "fusion energy/fusion science." Clarification is needed on whether plasma science is included in that phrase. All 12 facilities in the report were ranked either (a) or (b) for both questions 2a and 2b. The existence of facilities with lower rankings should be disclosed. The report's discussion of FPNS involves the need to "master" materials science, and "addressing whether materials retain adequate properties;" the language should be clarified in both cases. **Dr. Wirth** responded that detailing the white papers is outside the scope of the charge, but the white papers are available online. The short letter report stands on its own, and no table or graphs will be added.

Dr. Garrison's proposed amendments included clarification on the "with and without nuclear components" scenarios discussed in the report for BCTF, FCTF, HHF and FPNS; and clarification on the EXCITE section's description of milestone winners, facility composition and readiness for construction. **Dr. Paz-Soldan** objected: readiness levels for each EXCITE proposal will not be written. Concerning clarification on interpretation of the charge, **Dr. Wirth** objected. Appendix E already lists the criteria used to respond to the charge, and inclusion of a link to the full text of the white papers. **Dr. Wirth** agreed that a hyperlink will be added to the appropriate appendix. **Dr. Paz-Soldan** agreed and added that a third-party like Oak Ridge Associated Universities (ORAU) may be needed to facilitate the request as the white papers are currently on a private server.

Dr. Sutherland asked if international facilities other than ITER were considered to avoid

duplication of effort. **Dr. Wirth** mentioned that the recently approved FESAC international benchmarking report was accessible to the subcommittee, but the charge did not require evaluation of potential overlap. International input was sought for webinars involving HHF, specifically regarding the UKAEA Combined Heating and Magnetic Research Apparatus (CHIMERA) facility. Potential international partnerships were identified, but an exhaustive list was not created. **Dr. Allain** explained that duplication and international partners are all under evaluation, but U.S. leadership and domestic capabilities must also be considered.

Dr. Verboncoeur requested a summary table of science and technology gaps addressable by the facilities under consideration, along with cross-agency references suitable for assisting with the identified gaps. **Dr. Wirth** agreed with the usefulness of the suggestion, but explained that the task was outside the charge's scope and better aligned with the DP subcommittee.

Dr. Paz-Soldan encouraged the committee to mention any important partnerships excluded from the report.

Dr. Chacon commented on the many requests for clarification on how the rankings were balanced between a facility's impact to science and the ability to close technological gaps, indicating that the report does not properly communicate this issue.

An amendment was proposed by Dr. Chacon to rank scientific impact and the closing of technological gaps separately for each facility. **Dr. Paz-Soldan** objected, as separate ranking is outside the charge's scope and will not be done.

Dr. Wirth commented that previous suggestions from Drs. Guiton and Garrison to refine language about FPNS will be incorporated into the report.

Dr. Barish requested a motion for FESAC to approve the Draft FCP Subcommittee Report, with the changes that have been agreed upon. Dr. Walker will approve the revised draft report on behalf of FESAC. Dr. Matthews made the motion, and Dr. Esquisabel seconded the motion. As mentioned previously, six FESAC members were recused from both discussing the draft report and voting on it. The report passed with 19 approvals, one disapproval, and zero abstentions.

Update on the FESAC Decadal Plan Subcommittee, Dr. Troy Carter, Subcommittee Chair, University of California Los Angeles, and Dr. Tammy Ma, Subcommittee Vice Chair, Lawrence Livermore National Laboratory

Dr. Carter highlighted the major areas of focus in answering the DP charge. Areas include FES alignment to the LRP and BDV, the role of the public sector, and other overarching considerations. Alignment to the BDV is guided by the NASEM "Bringing Fusion to the U.S. Grid Report." Elements excluded from consideration include the U.S. contributions to ITER, AI/ML, the Material Plasma Exposure eXperiment (MPEX) project, and MEC-U. Roles of the public sector refer to mechanisms which address fusion materials and technology gaps, and the advance of commercial fusion applications. Consideration was also given to sustainable support for foundational research into synergies between discovery plasma science and fusion energy development. Overarching considerations include workforce continuity, diversity of the workforce, and continuing U.S. leadership in fusion and plasma science.

Subcommittee efforts have included weekly meetings with guest speakers, obtaining input from DOE to understand the charge's language, developing plans to address the charge, agreeing on community communications and requests for input, and starting work on the

alignment portion of the charge. The subcommittee has assessed the LRP, CPP, and other recent community-led reports as providing sufficient guidance for answering questions pertaining to alignment. No additional input regarding alignment will be sought.

The subcommittee's plans to address the role of the public sector is informed by the significant change in the fusion energy landscape, particularly the tripling of private investment to over \$6B. Two types of input are requested from the community: suggestions for speakers to deliver topic-relevant talks; and concise white papers addressing the charge, including proposals for new private-public partnership (PPP) mechanisms, proposals for improving the coupling of private and public efforts, and opportunities for synergies with fundamental and applied plasma science.

Next steps include breaking into groups to perform work on alignment based on the enacted FES FY24 budget, seeking input from FES program managers on their programs, continuing work on Zoom --with a possible in-person meeting in late June 2024, and the parsing of community input.

Discussion

Dr. Kuranz noted the several reports listed and asked if the nearly complete BRN report on Measurement Innovation will also be considered. **Dr. Carter** confirmed this and mentioned that Dr. Delgado-Aparicio is leading the BRN effort and is also on the DP subcommittee.

Dr. Verboncoeur noted the opportunity to address science and technology gaps. **Dr. Carter** agreed and mentioned that the LRP gives guidance for addressing the gaps.

Dr. Salazar asked how the current work incorporates the work of the FCP subcommittee. **Dr. Carter** explained that subcommittee leaders shared ex-officio status in both subcommittees to maintain mutual understanding and involvement. **Dr. Belli** noted the limited pool of authors contributing white papers, and asked how a broader portion of the community could be encouraged to participate. **Dr. Carter** agreed and will attempt different strategies to expand participation, including direct solicitation. **Dr. White** added that everyone should advocate for the website and share its QR code.

Dr. Wilson asked how the challenge of integration is being handled by the group. **Dr. Carter** explained that closing gaps could be approached through partnerships. Future white papers could address the barriers which exist in creating public to private and international partnerships

Dr. Agonafer mentioned being on the board of Howard University and asked if there was any interest in outreach to Historically Black Colleges and Universities (HBCUs) and whether assistance was needed. **Dr. Carter** confirmed this and expressed appreciation for the offer of assistance.

Dr. Paz-Soldan noted the interest in soliciting speakers and asked whether any presentations, specifically regarding PPP could become webinars. Webinars extend the subcommittee's effort to a wider audience. **Dr. Carter** agreed and mentioned that webinars have not yet been considered but would be a good addition.

Dr. Kuranz asked for ways that FESAC could provide support. **Dr. Carter** explained spreading the word and becoming advocates of the report is a great way to help. Suggestions for additions to the resource page would be appreciated. **Dr. Ma** added that FESAC could help review the many reports written by the community. The goal is to avoid relitigating the LRP.

Dr. Garrison asked if the next FESAC meeting would involve reviewing the final DP report or would there be interim meetings. **Dr. Allain** explained that the complexity of the charge would require interim feedback to the subcommittee. **Dr. Carter** agreed.

Public Comment

Dave Babineau (Director, Tritium Technology Division, SRNL) made comments on the following four areas: industry's role in advancing fusion; the balance of science and technology; U.S. competitiveness and international collaborations; and workforce development.

Private industry is playing a major role in driving efforts towards the advancement of fusion. SRNL has led fuel cycle and blanket workshops, in partnership with universities and the private sector, which have helped drive upcoming research objectives. The private sector was also involved with workshops on FPNS and a BRN workshop on IFE.

While technology is needed to make fusion power a reality, the technology will not work without scientific development. Two incidents were recounted, including a detritiation system and the scale-up of an isotope separation operation, in which the lack of scientific rigor led to equipment damage and the loss of millions of dollars.

International collaborations are important where they make sense. While ITER is a beneficial partnership, care must be taken to maintain U.S. leadership and competitiveness when sending work overseas. The tritium fuel cycle and weapons programs are areas of U.S. expertise which could asymmetrically benefit others. Care must be taken with dual use materials such as blankets, breeding, and tritium extraction and processing, which could evolve into lithium-6, lithium enrichment, and tritium development in deuterium heavy water. Foreign involvement brings the additional challenge of export control laws and regulations, which could increase project timelines and jeopardize success rates.

Finally, relying too heavily on a foreign workforce undercuts domestic development and negatively impacts both universities and the private sector. U.S. manufacturing needs further development. Purchasing tritium components is currently challenging due to the poor quality of parts on the market. SRNL must often instruct suppliers on how to correct defects in ordered parts.

Dr. White provided clarification on the COI process, and suggested members read four documents written by the Congressional Research Service (CRS), found at <https://crsreports.congress.gov/product/pdf/IF/IF12512/2> , which detail procedures required by FACA.

Dr. White adjourned the meeting at 4:38 p.m.

Respectfully submitted on May 17, 2024,

Patrick J. Cosme, Ph.D.

Science Writer for the Oak Ridge Institute for Science and Education (ORISE)

Minutes Approved by **Dr. White**  08-01-2024

FESAC Chair