FUSION ENERGY SCIENCES ADVISORY COMMITTEE

U.S. DEPARTMENT OF ENERGY

PUBLIC MEETING MINUTES

Virtual Meeting via ZOOM
September 18, 2023

Fusion Energy Sciences Advisory Committee Meeting
September 18, 2023

The U.S. Department of Energy (DOE) Fusion Energy Sciences Advisory Committee (FESAC) convened on Wednesday, September 18, 2023 via videoconference from 12:00 p.m. - 5:00 p.m. EDT. 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. Dereje Agonafer, University of Texas at Arlington
Dr. Luis Chacon, Los Alamos National Laboratory (LANL)
Dr. Luis Delgado-Aparicio, Princeton Plasma Physics Laboratory (PPPL)
Dr. Franklin Dollar, University of California Irvine
Dr. Stephanie Hansen, Sandia National Laboratories (SNL)
Dr. Paul Humrickhouse, Oak Ridge National Laboratory (ORNL)
Dr. Ralph Izzo, TerraPower
Dr. Edward Lahoda, Westinghouse Electric Company
Dr. Ane Lasa Esquisabel, University of Tennessee
Dr. Tammy Ma, Lawrence Livermore National Laboratory (LLNL)
Dr. Richard Magee, TAE Technologies
Dr. Lorin Matthews, Baylor University
Dr. Carlos Paz-Soldan, Columbia University
Dr. David Senor, Pacific Northwest National Laboratory (PNNL)
Dr. Bhuvana Srinivasan, University of Washington
Dr. Howard Wilson, ORNL

Committee Members Absent

Dr. Emily Belli, General Atomics
Dr. Susana Reyes, Excimer Energy

Ex Officio Members Present

Dr. Lauren Garrison, representing the American Nuclear Society, Fusion Energy Division (Commonwealth Fusion Systems)
Dr. Karl Krushelnick, representing the American Physical Society (APS), Division of Plasma Physics (University of Michigan)
Dr. John Verboncoeur, representing the Institute of Electrical and Electronics Engineers, Nuclear Plasma Sciences Society (IEEE INPSS) (Michigan State University)

DOE Personnel Present

Dr. Jean Paul Allain, Associate Director, FES, DOE Office of Science (DOE SC)
Dr. Sam Barish, FESAC Designated Federal Officer, FES, DOE SC
Dr. Asmeret Asefaw Berhe, Director, DOE SC
Dr. John Mandrekas, Research Division Director, FES, DOE SC
Mr. Joseph May, Facilities, Operations, and Projects Division Director, FES, DOE SC
Mr. Gene Nardella, Chief of Staff to the Associate Director, FES, DOE SC
Ms. Sandy Newton, FESAC Administrative Manager, FES, DOE SC

Approximately 153 individuals were present for all or part of the meeting.

Monday, September 18, 2023

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

Dr. White convened the meeting at 12:03 p.m., reviewed the changes to FESAC membership, and shared the meeting's agenda.

FESAC Charge on International Benchmarking, Dr. Jean Paul Allain, Associate Director, FES

Dr. Allain reviewed the charge to FESAC, which is available at https://science.osti.gov/fes/fesac/Meetings/2023-09.

Draft Report of FESAC Subcommittee on International Benchmarking, Dr. David Humphreys, FESAC Subcommittee Chair, General Atomics

Panels within the subcommittee covered five topics: the fusion core; materials and plasma-wall interaction (PWI); balance of plant; technologies; and fundamental plasma science. These panels generated subtopics in each area to create and assess metrics for potential research opportunities, which were then mapped to the FESAC Long Range Plan (LRP) science drivers and cross-cutting charge questions.

Charges 1 and 2a were addressed together. Charge 1 asks in what areas of research and on which international facilities are there compelling opportunities for U.S. researchers over the next ten years. Similarly, Charge 2a asks for the potential of these facilities to help U.S. scientists address priorities and recommendations in the LRP and the National Academies of Sciences, Engineering, and Medicine (NASEM) report "Bringing Fusion to the U.S. Grid." This is being done with the goal of increasing U.S. readiness for International Thermonuclear Experimental Reactor (ITER) operation and towards the Biden-Harris administration's Bold Decadal Vision (BDV) for commercial fusion.

In response to Charge 1, the subcommittee saw compelling opportunities for collaborative fusion core research in the following areas: tokamaks, spherical tokamaks (ST), stellarators, alternate magnetic fusion energy (MFE), and inertial confinement fusion (ICF)/ inertial fusion energy (IFE). The materials panel determined solid and liquid metal walls as important areas for plasma-facing components (PFCs), while highlighting the importance of fast spectrum reactors and spallation sources for high energy neutrons. Under balance of plant, resources at the Culham Centre for Fusion Energy (CCFE) in the United Kingdom were emphasized for blanket component testing and tritium processing research opportunities. In the technology spaces, the W Environment in Steady-state Tokamak (WEST) at the French Commissariat à l'Énergie Atomique (CEA) was spotlighted for ion cyclotron resonance heating (ICRH) in all-metal environments; the Max Planck Institute for Plasma Physics (IPP) in Garching, Germany and the National Institutes for Quantum Science and Technology (QST) in Japan were named as leaders in high energy continuous wave (CW) neutral beams. The panel also saw the importance of high temperature superconductor (HTS) magnet manufacturing capabilities at institutions like Tohoku University in Japan and the Robinson Research Institute in New Zealand. Within fundamental plasma science, ignition science, quantum electrodynamics (QED), and laser-plasma interactions were areas identified as ripe for collaboration.

With respect to Charge 2a, boosting ITER success and fusion pilot plant (FPP) design will require closing gaps in tokamak and ST physics within the fusion core. International tokamaks capable of closing these gaps include Japanese Torus-60 Super Advanced (JT-60SA),

the Divertor Tokamak Test (DTT) in Italy, and the Spherical Tokamak 80-High Temperature Superconductor (ST80-HTS) in the United Kingdom. Similarly, bulk materials and PFCs can benefit from international collaboration around irradiation and high heat flux studies at facilities such as the International Fusion Materials Irradiation Facility-Demo Oriented Neutron Source (IFMIF-DONES) in Spain and the Magnum-Plasma Surface Interaction (PSI) project in the Netherlands. To accelerate and expand design capabilities through theory and computation physics, a number of institutions such as the Institute for Magnetic Fusion Research (IRFM) at CEA, the Max Planck-Institute (IPP), CCFE, the Dutch Institute for Fundamental Energy Research (DIFFER), and the Swiss Plasma Center (SPC) were highlighted. Of note, engagement with the International Tokamak Physics Activity (ITPA) is essential for organizing international collaborations.

Among the findings and recommendations identified by Panel 1 for the fusion core, Wendelstein 7-X's (W-7X) status as the only optimized stellarator to likely exist in the near future was stressed. This emphasizes W-7X's importance for steady-state high power model validation and divertor studies. As a result, Panel 1 recommended expanding collaboration at W-7X, as well as at the helical-axis advanced stellarator (HELIAS) at IPP Greifswald and the Force Free Helical Reactor (FFHR) at the National Institute for Fusion Science (NIFS) in Japan on stellarator core physics and enhanced model validation capabilities.

Panel 2 focused on materials and plasma-materials interaction (PMI). Most notably, no suitable high flux PMI test stand for liquid metal PFCs exists either domestically or internationally. As a result, the panel recommended leveraging the Experimental Advanced Superconducting Tokamak (EAST) in China, the Compact Assembly-Upgrade (COMPASS-U) in Czechia and DTT liquid metal PFCs to advance U.S. expertise until a liquid metal divertor is installed at PPPL's National Spherical Torus Experiment-Upgrade (NSTX-U).

Balance of plant was the concentration of Panel 3; one finding called out a 2020 U.S.-European Union (EU) technical workshop which identified critical priorities in this area. Based on the findings of this workshop, the panel recommended the pursuit of collaborations in safety assessment, nuclear design integration, tritium permeation and handling, magnetohydrodynamic (MHD) flow in blankets, and waste management.

Technology was covered in Panel 4, which found that the U.S. lacks at-scale manufacturing capability and commensurate magnet test facilities for rare-earth barium copper oxide (ReBCO) tapes. As a result, the panel recommended supporting collaborations with the High Field Laboratory for Superconducting Materials (HFLSM) at Tohoku University, the Robinson Institute, and the SUpraLeiter TestANlage (SULTAN) in Switzerland to advance these capabilities.

Panel 5 covered the fundamental understanding of plasmas. Subtopics covered plasma states, laser-plasma interactions, foundational materials, and basic applications.

The subcommittee also explored cross-cutting topics that covered all panels, focusing mostly on theory, algorithms, and computation. In particular, international collaborations in machine learning (ML), artificial intelligence (AI), and control mathematics have strong potential for advancing BDV goals. Collaborations in these areas with the Research Consortium for Energy and Technology Application of Electromagnetics (CREATE) in Italy, DIFFER, and SPC might accelerate U.S. capabilities and help prepare for ITER operations.

In Charge 2b, the subcommittee was asked to assess whether the existing modes of collaboration are adequate for maximizing the impact of international collaborations. The findings show how essential strong frameworks and an established definition of collaboration

are; collaborations should be run like true projects with schedules, goals, deliverables, and project controls to maximize impact. For experiments, device schedules are fluid and require close communication; dynamic reassignment is frequently needed. Similarly, technology development has distinct differences from testing collaborations, but also requires scheduling, user procedures, and safety coordination like experiments do. Within theory and foundation science, high bandwidth and low latency cyber access is necessary for collaborations, along with the use of data standards and modern software management. International agreements, networks and structures, ease of onboarding, and the on-site location of participants are vital in this area.

Because the existing modes of collaboration incorporate a wide range of practices, varying in effectiveness and impact on the U.S. fusion program, the subcommittee identified best practices for Charge 2b rather than assess specific collaborations. Experimental collaborations require a clear understanding of device and facility use, operation, communication hierarchies, and safety procedures. Success in theory and computation science collaborations necessitates low administrative barriers to cyber access, data, and computer resources – ease of software sharing with management and protection of intellectual property (IP) are vital. Similarly, technology collaborations require explicit handling of IP and invention provenance from the outset, along with specific training for safety and user procedures.

Charge 3 asks how the U.S. can advance commercial fusion through the fusion private sector in international engagements and public-private partnership programs. In this context, the subcommittee found that private companies often have limited experimental resources and need access to other facilities to test components and subsystems. As a result, the major recommendation is creating public-private partnership programs to facilitate the collaboration of domestic private companies and international resources to accelerate the development of fusion technology and commercialization. Collaborations supported through this program should be limited in scope but bear well-defined deliverables and strike a clear balance between openness and IP protection. Successful agreements like SC's Innovation Network for Fusion Energy (INFUSE) program and Cooperative Research and Development Agreements (CRADAs) might be used as models in this area.

Under Charge 4, the subcommittee was asked to identify which FES research areas the U.S. is leading, not leading, or in which leadership is threatened. The U.S. leads and is not significantly threatened in many aspects of tokamak physics, including the demonstration of high-performance scenarios in short pulse lengths, disruption avoidance, mitigation physics and control, and core-edge integration. However, the U.S. lacks the large facilities to maintain overall leadership in their operations; superconducting tokamaks and burning plasma experiments are only accessible through international collaborations. As a result, the U.S. should leverage international collaborations on large-scale fusion facilities to develop and maintain the necessary skill set in building, operating, and executing fusion research at scale.

In the ICF and IFE areas, the U.S. is the international leader, but growing and maintaining that leadership will require keeping the science open to international collaboration while still retaining and protecting U.S. IP. Gyrotron source development and the testing and diagnostic development for high repetition rate lasers were two technology areas identified where the U.S. is not leading and could benefit from international collaboration. The importance of identifying and satisfying U.S. national leadership goals in international collaborations was stressed; clearly identifying the anticipated roles in international collaborations should be part of a national strategy for technical advancement and leadership.

Charge 5 asks how the U.S. can ensure an internationally competitive workforce for fusion, including the recruitment of talent from traditionally underrepresented groups within the U.S. In this context, the subcommittee saw workforce expansion being accomplished both domestically and internationally, through universities, government laboratories, private industry, and non-fusion science, technology, engineering, and mathematics (STEM) areas. The need to expand the domestic workforce in manufacturing, engineering, and technician work to fulfill the BDV will require engaging students and early career professionals with support from domestic and international private industry. Tradesmanships and internships in manufacturing, engineering, and technician training are vital and should offer opportunities to those with non-advanced degrees.

Discussion of Draft Report on International Benchmarking, Dr. Anne White

Dr. Allain asked about closing gaps around tokamak and ST physics and whether an agreement was found between the timescale of the BDV and the various roadmaps of international partners, especially in context of existing facilities and new facilities coming online. **Dr. Humphreys** said that the subcommittee was thinking about this on a ten-year timescale. **Dr. Nate Ferraro** (PPPL) mentioned that the constraints of the BDV timescale will require some developments to occur simultaneously as much as possible. Moving towards building a pilot plant and the next generation of facilities will require taking more risks and collaboration.

Dr. Agonafer asked whether Panel 1 focused on multi-design variables, multi-objective optimization, and co-design of stellarators and core physics. **Dr. Ferraro** mentioned Panel 1's focus on existing facilities and noted efforts towards a multi-objective optimization to minimize neoclassical turbulence and fast particle transport within the constraints of manufacturable and maintainable blankets and coils.

Dr. Verboncoeur asked about the omission of semiconductor materials as one of Panel 5's subtopics. **Dr. Humphreys** explained the prioritization of basic applications in this area; semiconductor materials ranked low compared to areas such as space propulsion, agricultural plasma, and plasma medicine. **Dr. Allain** suggested considering nontraditional plasma processing topics such as plasma nanosynthesis and similar areas. **Dr. Verboncoeur** emphasized outstanding basic research questions around semiconductors, such as substrates and material compatibility, which may be relevant to plasma-facing materials.

Dr. Agonafer asked how disruptive semiconductor technologies might be integrated into these collaborations. **Dr. Humphreys** emphasized the importance of data-driven and data-intensive approaches, but the report does not specifically focus on new approaches in semiconductor processing. This might be a topic to cover in a format similar to the FESAC Transformative Enabling Capabilities for Efficient Advance Toward Fusion Energy report released in 2018. **Dr. Allain** stressed the importance of supply chain in this area, especially in light of materials development and manufacturing. **Dr. Verboncoeur** mentioned the opportunities around radiation mitigation for chips and systems.

Dr. Delgado-Aparicio asked about international collaboration opportunities around alternative concepts such as reverse field pinches (RFPs), zeta pinches (Z-pinches), and field-reversed configurations (FRCs). **Dr. Ferraro** mentioned the section of the report that calls out international alternative confinement facilities; due to the U.S.'s focus on tokamaks and stellarators, collaborations with alternative configurations in foreign facilities should be leveraged. **Dr. Barish** shared the subcommittee's recommendation to support international

collaborations on alternative magnetic confinement concepts between domestic and international partners.

Dr. Allain asked about the criticality of high-level agreements, such as memoranda of understanding (MOUs), between institutions in the context of collaborations. **Dr. Humphreys** highlighted the importance of international agreements and cross-facility agreements, which may come in the form of MOUs, but also might include non-disclosure agreements (NDAs) and IP specifications.

Dr. Lahoda first inquired whether international collaborations entail researchers working together or sending money to facilities; second, what is the fate of data stemming from these collaborations? **Dr. Humphreys** saw all collaborations having some level of personnel engagement; however the range of that engagement can vary. The report emphasizes small-scale collaborations; a single person working with another single person can be very effective. The fate of research data depends on the type of research being done, but documentation of some sort is critical for all collaborations.

Dr. Hansen emphasized the importance of information sharing and the potential benefits of small-scale collaboration between DOE laboratory employees and universities. Either small amounts of funding or small collaboration groups might help share priorities and increase awareness of research topics.

Dr. Allain emphasized thinking about broad international partnerships with the Global South as a way to create pathways to attract talent to the U.S.

Dr. Delgado-Aparicio discussed the difficulties of deploying people abroad for an extended period. **Dr. Humphreys** stressed the importance of optimizing the design of collaborations from the outset, deciding when it is truly beneficial to have someone on site for long-term stays; this may be an area worthy of more focus and specificity in the report. **Dr. Arianna Gleason-Holbrook** (Stanford University) mentioned how the workforce section of the report addresses enabling the mobility and presence of international researchers in experiments.

Dr. Verboncoeur wondered about encouraging out-of-the-box and high-risk research in academia, which might then be moved to industry or government labs, especially in light of leveraging private capital.

Dr. Srinivasan suggested financially incentivizing institutions to create more faculty positions in fusion technology, science, and engineering. **Dr. Humphreys** stated that the report does mention support for educators, as well as supporting positions in other disciplines such as materials scientists, mathematicians, computer and data scientists, systems engineers, project managers, and computer-aided design (CAD) technicians.

Dr. Wilson commented on attracting engineering talent in private industries which are adjacent to fusion; these workers can be easily retrained to work in this area. **Dr. Humphreys** welcomed this suggestion.

Dr. Agonafer suggested a one-week fusion energy module undergraduate engineering course as a path toward workforce growth. **Dr. Humphreys** agreed with this comment and stressed the need for educational modules for all grade levels and for staff transitioning in from other engineering disciplines.

Dr. Verboncoeur indicated that the best way to increase the graduate student pipeline is to increase research funding in a reliable and long-term manner, which will eventually result in hiring of additional faculty. Traineeships and internships in domestic and international facilities are also important mechanisms in this area. **Dr. Srinivasan** suggested funding efforts for faculty positions at institutions that have not supported fusion research in the past to increase diversity in

this area. **Dr. Humphreys** mentioned the potential for apprenticeships and internships for technicians moving to fusion from other fields of work.

Dr. Paz-Soldan noted the enthusiastic discussion on workforce development and suggested a dedicated FESAC charge in this area.

Dr. Barish dismissed the meeting at 2:30 p.m. for a break and reconvened at 2:45 p.m.

Introduction of the Director of the Office of Science, Dr. Jean Paul Allain

Dr. Allain introduced Dr. Asmeret Asefaw Berhe.

Office of Science Perspective, Dr. Asmeret Asefaw Berhe, Director, Office of Science

Dr. Berhe welcomed the new FESAC members, thanked continuing members for their service, and recognized Dr. Allain's appointment to Associate Director of FES.

The draft International Benchmarking Subcommittee Report on International Collaboration will help set priorities and advance FES program activities.

The Biden-Harris administration continues to prioritize the commitment to a pilot-scale demonstration of fusion, which is evident in the recent announcement of $46M in DOE funding to eight companies advancing designs, and research and development for a fusion power plant. This funding from the Milestone-Based Fusion Development Program will solidify U.S. leadership in fusion commercialization and is one step in the President's approach to reaching net-zero carbon emissions by 2050.

Dr. Berhe enjoyed visiting completed and in-progress fusion-related facilities, mentioning a number of tokamaks in the U.S. and abroad. Similarly, praise was shared for the IFE research at LLNL's National Ignition Facility (NIF), especially around the historic achievement of fusion ignition in December 2022.

Diversity, equity, and inclusion (DEI) are major priorities for the DOE; DEI is a vital part of solving fundamental scientific and technological challenges such as the pursuit of fusion energy. Investing and building an inclusive workforce is key to scientific success moving forward.

Discussion

Dr. Agonafer asked about adding fusion-related topics into undergraduate curriculums. **Dr. Berhe** saw how such topics could fit into undergraduate physics and engineering courses, but might also reach students more broadly through earth and environmental sciences courses. Today's college students have a passion for the environment and climate solutions.

Discussion of Draft Report on International Benchmarking (continued), Dr. Anne White

Dr. Humrickhouse spoke on the methodology behind the metrics in highlighting specific international facilities. The facilities ended up being either large-scale, where building a domestic equivalent is costly and has a long lead time, so collaboration is impactful in building knowledge in the short-term; on other hand, the small-scale facilities can provide hands-on experience that is transferrable to domestic facilities in the short-term. Similarly, the subcommittee considered gaps in research capabilities for domestic and international scientists to spur collaboration. **Dr. Wilson** emphasized the need to think about these gaps now and within the timespan of the next four to seven years to leverage and maximize these relationships.

Dr. Magee mentioned the removal of recommendations around regional hubs from the report, as they are out of scope for this charge. Addressing the topic of facilities that appear in the report's text, but not tables: for Panel 1, these are facilities that might be useful, but are no longer in operation or seem to be decommissioned. **Dr. Lasa Esquisabel** responded and called out disruption mitigation and divertor physics as examples of topics which are discussed in the report which do not appear in the recommendations.

Dr. Paz-Soldan found the brief mention of the Joint European Torus (JET) in Finding F1-1 to not fully emphasize the importance of this facility and the unique data it can offer the U.S. community. Lack of details around the particulars of the private sector's involvement in international collaborations was also mentioned; what model should be used in this area? **Dr. Humphreys** acknowledged these comments and mentioned the private sector's involvement as part of a financing section that was eventually removed from the report.

Dr. Garrison sought more information about what mechanisms might be used to connect private industry with international facilities for collaboration. **Dr. Humphreys** saw the need for a ground-up effort that deliberates on private industry's challenges in this area and to address them in a new way. **Dr. Garrison** agreed with that approach and asked about the potential for collaboration at international fission test reactors. **Dr. Livia Casali** (University of Tennessee) saw this as a major topic that will require discussion with international partners to address. **Dr. Kevin Field** (University of Michigan) emphasized discussion centered around moving samples from fission reactors, as that is a significant challenge when compared to doing the experimentation itself.

Dr. Hansen cautioned against letting the report's topical focus areas be taken as implicit recommendations for down-selection; this might take away the focus from innovative or disruptive technologies and research efforts. **Dr. Humphreys** understood and appreciated this comment.

Dr. Casali emphasized the importance of immigration requirements as part of a robust workforce development framework. **Dr. Humphreys** agreed with this; creating a pipeline of international experts requires immigration to the U.S. to be feasible.

Dr. Delgado-Aparicio pointed out the lack of details around a broader approach to advance quantum science research internationally. **Dr. Humphreys** said the report deliberately avoided broad statements but called out specific facilities in this area, including IFMIF-DONES and JT-60SA. **Dr. Allain** confirmed that a broader approach will require strategizing over domestic priorities, which is part of a larger conversation to be guided by the recommendations of this report.

Dr. White invited specific comments about suggested changes to the report.

Dr. Scott Hsu (DOE Office of the Under Secretary for Science and Innovation) suggested additional columns in the report's tables specifying the U.S.'s level of capabilities in the topic area, as well as differentiating between existing facilities and anticipated facilities. Second, the word 'reactor' in the context of fusion should be changed to 'fusion system' to distinguish between fission energy. **Dr. Humphreys** explained that identifying the state of U.S. capabilities is out of scope, but will make sure all facilities are marked as either existing or anticipated. **Dr. Ferraro** saw challenges in doing this, as each facility has unique aspects that are difficult to capture in table format. **Dr. Humphreys** explained that the report does something similar in calling out high-level capabilities in topical areas without calling out specific resources. **Dr. Barish** recounted discouraging the subcommittee in including details of U.S. facilities, as it is outside the scope of the charge. **Dr. Humphreys** expressed concern about the

applicability of the information being requested to future international collaborations. **Dr. Hsu** asked whether what is in the body of the report with respect to this subject might be summarized at a high level. **Dr. Bonoli** stated that the recommendations map the findings throughout the text, which achieves a similar effect to what was requested. **Dr. Paz-Soldan** mentioned Charge 4 as a place to highlight facilities and areas in which the U.S. are leaders. **Dr. Humphreys** saw this as reasonable and a way to give actionable information. **Dr. Wilson** wondered if this could be extended to what future facilities and areas might further strengthen U.S. leadership positions, especially in light of the BDV. **Dr. Humphreys** summarized these suggestions to augment the leadership assessment table in Section VII to include a description of existing and potential U.S. capabilities in addressing gaps. These changes were approved and delegated to Dr. Bonoli and Dr. Paz-Soldan. Similarly, Dr. Hsu's suggestion of avoiding the word 'reactor', to be replaced with 'fusion system' was approved; **Dr. Verboncoeur** expressed a preference for 'fusion energy system'.

Dr. Delgado-Aparicio brought up the suggestion to add details about radiation hardening to Section VII, which was approved.

Dr. Lahoda called out instances in the report where the phrase 'high rep rate' was used and recommended using 'high rep rate lasers' instead for added clarity. **Dr. Gleason-Holbrook** explained that 'high rep rate' refers to higher repetition rate data intake and reduction; this term is not always laser-specific and will be revisited for clarity. The suggestion to clarify this term was approved, and the necessary changes were delegated to Dr. Gleason-Holbrook.

Dr. White then brought up and approved the suggestion for the Axially Symmetric Divertor Experiment (ASDEX) at IPP to be included as a facility under Recommendation 1-1.

Dr. Izzo asked the subcommittee to be mindful of the U.S. Supreme Court's recent affirmative action decision in the context of workforce development and diversity.
A suggestion to ensure inclusive workforce development and diversity language that is also consistent with legal requirements was approved and delegated to Dr. Humphreys.

Dr. Gleason-Holbrook suggested two items; first was to call out opportunities in microelectronics and nanoelectronics in relation to plasma physics and PSIs, which was approved and delegated to Dr. Gleason-Holbrook and Dr. Verboncoeur. Second was adding details about pulsed power drivers, specifically through an international lens; this was approved and delegated to Dr. Gleason-Holbrook, Dr. Ma, and Dr. Hansen.

Dr. Paz-Soldan asked for further details in the report around ICF and how collaborations in this area can be leveraged. **Dr. Humphreys** explained that the report erred on the side of not making specific suggestions around programs. This suggestion was not approved.

Dr. Lasa Esquisabel proposed changing the language in Recommendation 4-4, which looks for world leadership in the construction and operation of large-scale facilities to something more realistic. **Dr. Humphreys** believes the language should be changed to improving the level of U.S. expertise, consistent with the BDV and matches the language in the narrative. **Dr. Wilson** wondered if matching the BDV would imply world leadership and whether the current language might feel weak. **Dr. Humphreys** saw this as a difference in the definition of leadership; it is acceptable for the U.S. to be at parity with the rest of the world in this area. **Dr. White** saw this as two separate suggestions: first, changing Recommendation 4-4 to match what the narrative says so the language is internally consistent; and then to make sure the report clearly defines the terms 'leadership' and 'parity'. This was approved and delegated to Dr. Humphreys.

Dr. Lasa Esquisabel raised the issue of identifying text that is found within recommendations, but is not in the narrative, and amending that for consistency, which was approved and delegated to Dr. Humphreys and Dr. Bonoli.

Dr. Lasa Esquisabel suggested correcting typos, especially involving the word 'divertor', which was approved.

Dr. Srinivasan shared ITPA as an acronym which was not defined in the glossary. **Dr. Chacon** indicated CW and the Material Plasma Exposure eXperiment (MPEX) as other acronyms which were not defined, while **Dr. Matthews** said ST was missing a definition as well. The suggestion to ensure all acronyms were defined was approved.

Dr. Lasa Esquisabel mentioned examples of sentence fragments to be revised; **Dr. Matthews** found a punctuation issue as well. This suggestion was approved, and a careful proofreading will be done.

Voting on the Recommendations and the Report, Dr. Sam Barish

Dr. Barish initiated the voting process on the report and the changes recommended above; **Dr. Matthews** motioned to accept the report with these changes. The motion was seconded by **Dr. Lasa Esquisabel**. Upon conclusion of the voting, it was passed unanimously with 16 'yes' votes.

Next, all recommendations in the report with the noted changes except Recommendations 1-3; 3-1; 3-3; 5-5; and 2a-4 were voted upon. **Dr. Humrickhouse** motioned to accept these recommendations and was seconded by **Dr. Srinivasan**. This vote passed unanimously with 16 'yes' votes.

Recommendations 1-3; 3-1; 3-3; and 5-5 with the discussed changes were presented for a vote of approval. A motion was made by **Dr. Chacon** and was seconded by **Dr. Lahoda**. As there were recusals on these Recommendations, the vote passed unanimously with 14 'yes' votes.

In the final vote, Recommendation 2a-4 was presented. **Dr. Matthews** motioned to accept this recommendation, which was then seconded by **Dr. Lasa Esquisabel**. As there was a recusal on this Recommendation, this vote passed unanimously with 15 'yes' votes.

Dr. White confirmed the voting results and thanked the subcommittee for its hard work on the report. **Dr. Humphreys** expressed gratitude for the comments shared during the meeting.

Dr. Barish explained the next steps in the process; after the discussed changes are made, Dr. White will review the revised report and approve it on behalf of FESAC. Then, Dr. White will send the final report to Dr. Berhe (Director of the Office of Science) with an accompanying transmittal letter. After that step, the report will be posted on the FES website. **Dr. Bonoli** asked for a timeline in which the changes must be made. **Dr. Humphreys** suggested a deadline of October 9, 2023.

Public Comment

No public comment.

Dr. White adjourned the meeting at 4:49 p.m.

Respectfully submitted
Drew Nitschke
Science Writer, Oak Ridge Institute for Science Education (ORISE)

Reviewed and Approved

Dr. Anne White (FESAC Chair), Massachusetts Institute of Technology (MIT)

October 21, 2023