

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

PUBLIC MEETING MINUTES

Virtual Meeting
September 30, 2024

Fusion Energy Sciences Advisory Committee Meeting September 30, 2024

The United States (U.S.) Department of Energy (DOE) Fusion Energy Sciences Advisory Committee (FESAC) convened on Monday, September 30, 2024, for a virtual Zoom meeting from 10:00 a.m. - 4:12 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. Emily Belli, General Atomics
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. Ane Lasa Esquisabel, University of Tennessee
Dr. Brenda Garcia-Diaz, Savannah River National Laboratory (SRNL)
Dr. Beth Guiton, University of Kentucky
Dr. Ralph Izzo, Terra Power
Dr. Eva Kostadinova, Auburn University
Dr. Carolyn Kuranz, University of Michigan

Dr. Edward Lahoda, Westinghouse Electric Company
Dr. Lorin Matthews, Baylor University
Dr. Carlos Paz-Soldan, Columbia University
Dr. Susana Reyes, Excimer Energy
Dr. Erica Salazar, Commonwealth Fusion Systems (CFS)
Dr. David Senior, Pacific Northwest National Laboratory (PNNL)
Dr. Andrew Sowder, Electric Power Research Institute (EPRI)
Dr. Bhuvana Srinivasan, University of Washington
Dr. Mitchell Walker, Georgia Institute of Technology
Dr. Howard Wilson, Oak Ridge National Laboratory

Committee Members Absent

Dr. Dereje Agonafer, University of Texas at Arlington

Dr. Derek Sutherland, Zap Energy

Ex Officio Members Present

Dr. Edward Thomas, American Physical Society, Division of Plasma Physics, Auburn University
Dr. John Verboncoeur, Institute of Electrical and Electronics Engineers, Nuclear and

(IEEE NPSS), Michigan State University (MSU)
Dr. Lauren Garrison, American Nuclear Society, Fusion Energy Division, CFS

DOE Personnel Present:

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

Dr. Sam Barish, FESAC Manager

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

Approximately 180 individuals were present for all or part of the meeting.

Monday, September 30, 2024

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

Dr. White convened the meeting at 10:00 a.m., and called for a moment of silence in memory of Professor Bill Dorland, who passed during the previous week.

The purpose of FESAC meetings, and details on its members and subcommittees were reviewed. The FESAC Decadal Plan (DP) subcommittee will present a second update, including progress and processes. Recommendations will be excluded, as the collection of input from the community and deliberations are ongoing. The DOE Office of General Counsel has determined that Dr. Salazar, Dr. Sutherland, and Dr. Srinivasan should be recused from discussing the subcommittee's update.

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

Dr. Kung shared the fiscal year 2025 (FY25) research budget request for SC, which represented strong support from the Biden-Harris Administration. Requests were for \$8,583M, representing an increase of \$343M or 4.2% over FY24 appropriations. Increased investments in Administration priorities will include: artificial intelligence (AI) with a \$93M increase over FY24 to \$259M; Fusion Innovation Research Engine (FIRE) Collaboratives +\$15M, \$60M; Reaching a New Energy Sciences Workforce (RENEW) +\$69M, \$120M; Funding for Accelerated, Inclusive Research (FAIR) +\$32M, \$64M; research on climate change and clean energy \$20M; Microelectronics +\$22M, \$95M; and SC Energy Earthshots +\$95M, \$115M. The laboratory, facility operations, and projects request included upgrades to core laboratory infrastructure +\$32M, \$50M; continued funding for the Laboratory Operations Apprentice Program +\$2M, \$5M; support for facility operations at ~88% optimal funding levels; and ongoing scientific user facility upgrade construction projects and ongoing infrastructure projects.

The House mark funds SC at \$8,390M, \$150M over the FY24 enacted budget, and \$193M below the FY25 request. Details include \$245M for quantum information science (QIS) research; \$15M for research in support of the Quantum User Expansion for Science and Technology program (QUEST); \$20M for testbeds to integrate high performance computing and quantum (flat with the request); \$20M for SC Energy Earthshots (\$95M below the request); \$40M for FIRE Collaboratives (\$20M below the request); support for the expansion of microelectronics research, including Microelectronics Science Research Centers (MSRCs); no funding for RENEW or FAIR initiatives; and the establishment of a Carbon Sequestration Research and Geologic Computational Science Initiative. Most construction projects are funded at or near the request.

The Senate mark funds SC at \$8,600M, \$360M over the FY24 enacted budget, and \$17M over the FY25 request. Details include \$160M for artificial intelligence/machine learning (AI/ML) research and \$100M for Frontiers in Artificial Intelligence for Science, Security and Technology (FASST) (~flat with the request); not less than \$265M for QIS research, including five national QIS research centers (\$15M below the request); \$60M for SC Energy Earthshots (\$55M below the request); \$110M for microelectronics (\$15M below the request); not less than \$45M for FIRE Collaboratives (\$15M below the request); support for RENEW and FAIR initiatives; and \$25M to establish a Carbon Sequestration Research and Geologic Computational

Science Initiative and \$10M for atmospheric methane removal research. Most construction projects were funded at or near the request.

SC leadership and organizational changes were announced. FASST is DOE's new signature initiative to advance the AI frontier. The initiative supports mission needs of national security, energy security, and scientific discovery, and consists of four pillars: AI-ready data; frontier-scale AI computing infrastructure and platforms; safe, secure, and trustworthy AI models and systems; and AI applications. The initiative aims to prevent the U.S. from losing its competitive scientific edge, catalyze a diverse and competitive innovation AI ecosystem, build technical expertise, and attract and train a talented workforce. The fusion and plasma science community was encouraged to participate in a request for information (RFI) which will close in November 2024.

DOE research, technology, and economic security (RTES) policies must address a wide range of risk levels. A key consideration is the balance of promoting international collaboration, while protecting against undue foreign influence, without compromising the core values of openness, transparency, parity of intellectual and financial contributions, and mutual respect for intellectual property (IP) rights. Notable events in the RTES timeline include the National Security Presidential Memorandum 33 (NSPM-33) of 2021, which codified research security requirements and policy; the NSPM-33 implementation guidance of 2022; and the Office of Science and Technology Policy (OSTP) guidelines for research security programs at covered institutions released in 2024.

Recent changes in RTES policy focus on foreign engagements, with increased emphasis on transparency and relevant disclosures. The RTES Policy Working Group (PWG) was formed to address policy development and consistency with interagency processes and is working to update DOE financial assistance (FA) policies. The Office of Research, Technology and Economic Security (RTES Office) was formed to provide consistency and support for due diligence reviews and risk mitigation in FA and loan activities. Diligence reviews occur in three phases: phase 1 involves funding opportunity announcement (FOA) review; phase 2 involves proposal review; and phase 3 monitors the project for changes in foreign connections, and devises strategies for risk mitigation as needed. The office will also publish and distribute risk matrices, on which fusion and plasma science community feedback is requested.

The national laboratory security policy involves an S&T risk matrix to manage critical and emergent technologies which otherwise lack control mechanisms. The matrix is color coded and defines technology and topics as either green, not sensitive to economic or national security; yellow, having potential sensitivity and may require protective measures; and red, having security sensitivity and requiring protective measures. The policy only applies to countries of concern (China, Russia, Iran, and North Korea) and specially designated activities.

Interagency coordination and community engagement are important aspects of the security policy. Dr. Kung will continue to participate as co-chair on the National Science and Technology Council (NSTC) Subcommittee on Research Security, continue to engage with like-minded allies and partners through state department-led efforts, and increase public-facing engagements with leaders and members of organizations such as the Fusion Development Program (FDP), the Council on Governmental Relations (COGR), the Association of American

Universities (AAU), and the Association of Public and Land-Grant Universities (APLU), as well as with the Asian American and Native Hawaiian/Pacific Islander research community.

Discussion

Dr. Kuranz asked for SC's strategy to protect key information and maintain research security, while moving towards open science and transparency. **Dr. Kung** explained that the process begins with raising awareness and demonstrating to Congress that robust mechanisms exist to prevent the unintended sharing of information. Advice will be sought from security experts, education campaigns will aim to instill a deep understanding of how to identify and protect sensitive information, and efforts will be taken to reduce the burden of protection on industry.

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

Dr. Allain recognized the seminal contributions of Professor Bill Dorland in plasma physics and his many prestigious awards in the field.

The vision and direction of the FES program, and plans for its integration into a broader DOE strategy, are captured in two publications: *Building Bridges: A Vision for the Office of Fusion Energy Sciences* and *Fusion Energy Strategy 2024*, which were released at the recent White House (WH) Bold Decadal Vision II Event, and is available online at <https://www.energy.gov/fusion-energy>. The three pillars of the fusion strategy are closing science and technology (S&T) gaps to a Fusion Pilot Plant (FPP); preparing a path to commercial deployment; and building and leveraging external partnerships, which will be supported through leveraging FES tools. Tools include the Fusion S&T Roadmap, the Fusion Innovation Research Engine (FIRE) Collaboratives, the Milestone Program, and the Public-Private Consortium Framework for Fusion Energy. Fusion strategy is also supported through FES collaboration with DOE entities outside of SC, including the National Nuclear Security Administration (NNSA), the Advanced Research Projects Agency–Energy (ARPA-E), the Office of Nuclear Energy (NE), and the Office of Technology Transitions (OTT).

A well-defined roadmap, including metrics to track progress, is important to attaining an FPP. The Fusion S&T (FS&T) Roadmap will address key science drivers by identifying S&T gaps and methods to close the gaps. Other aspects of the roadmap involve integrating industry input, guiding priorities and partnerships, and undergoing regular updates to meet industry and research and development (R&D) needs.

An updated FES budget structure organizes fusion and plasma research into five categories: theory and simulation, fusion materials and internal components, sustain a burning plasma, closing the fusion cycle, and discovery plasma science and technology. Cross-thread programs include Fusion Science & Technology Facilities, FIRE Collaboratives, Public-Private Partnerships (PPP), Fusion Workforce Pathways, and the International Thermonuclear Experimental Reactor (ITER). Budget restructure efforts have also impacted several programmatic elements, including a new Private Facility Research (PFR) program in the Enabling Science and Partnerships Division. The PFR program represents a bridge to the private sector and sponsors publicly funded researchers to conduct open scientific studies on private facilities, for public benefit. The FY25 PFR pilot program builds on previous model project success and opens research opportunities to compete across all private devices and facilities in

the U.S. and the world. Additional elements include three stand-out programs in the Research Division: Emergent Confinement Concepts, Toroidal Long Pulse, and Compact Toroidal Concepts, all which support efforts to sustain a burning plasma.

Efforts to de-risk fusion and plasma science, and bridge the S&T gaps identified by the Long Range Plan (LRP), focus on improving relative technical readiness level (TRL) scores currently between zero and four, to a seven. Partnerships will play an important role and have been the topic of multiple conversations with the private sector and local state governments. The impact of FY24 and FY25 investments in Theory and Simulation, particularly in AI/ML, exemplifies the potential of partnerships to address gaps. Work and investments in ITER represent another key partnership, with U.S. contributions resulting in the recent completion of hardware systems.

Input from the FESAC Facilities Construction Projects (FCP) report will be combined with input from community-based workshops held from 2022-2024, and other FESAC reports, to help define prioritization in the FS&T Roadmap. The Measurement Innovation Basic Research Needs (BRN) workshop chaired by Dr. Delgado-Aparicio was highlighted as particularly beneficial. The Innovation Network for Fusion Energy (INFUSE) was highlighted as a highly successful PPP element. To date, INFUSE has made 107 awards totaling \$24.2M, supporting 34 private companies in partnering with 10 DOE labs and 12 U.S. universities. Efforts continue on the Milestone Program, FES's signature PPP program.

Recent private sector developments were highlighted, including Zap Energy achieving 37 million degrees Celsius temperatures in a compact device; Realta's Wisconsin High-temperature superconductor Axisymmetric Mirror (WHAM) experiment achieving first plasma with 17 Tesla magnets in a mirror fusion test; Occidental Low Carbon Ventures and TAE Technologies exploring fusion energy for direct air capture facilities; and Type One Energy announcing a \$200M+ public-private investment in collaboration with the Tennessee Valley Authority and ORNL to build Infinity One, a stellarator fusion prototype machine.

Developing the FES re-structure and National FS&T Roadmap timeline will involve an external vendor and will include input from the community, forums and workshops. Additional details will be shared in a subsequent presentation.

Discussion

Dr. Verboncoeur sought discussion on the challenges of integrating PPP into RTES, including the management of IP and the development of instruments regarding Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. **Dr. Allain** acknowledged the difficulties, and explained that the process will be lengthy and involve layers which must be tailored to the specific stakeholders, entities, and PPP involved.

Update from the FESAC Decadal Plan Subcommittee Professor Carlos Paz-Soldan, Subcommittee Chair, Columbia University and Dr. Tammy Ma, Subcommittee Vice Chair, LLNL

Dr. Paz-Soldan outlined the presentation and introduced Dr. Ma.

Dr. Ma thoroughly described the DP charge, reading through multiple sections and highlighting specific language. The DP charge, issued in December 2023, encouraged the reassessment of the FES program's alignment with the FESAC LRP, and program expansion to

address the U.S. Bold Decadal Vision (BDV) in a decadal timeframe. The full text of the charge is available on the FES website.

Dr. Paz-Soldan announced being named the new subcommittee chair, replacing Dr. Troy Carter who moved to ORNL last July, and introduced subcommittee members and affiliations.

Dr. Ma described the subcommittee's timeline and process. The group meets about six times a week, has solicited community input through whitepapers and invited speakers, conferred with FES program managers, incorporates community reports released from 2019 to 2024, and conducts polls of members. The group is also influenced by the community-led consensus report which resulted from the American Physical Society, Division of Plasma Physics Community Planning Process (APS DPP CPP) report of 2020 and the LRP. Additional community solicitations included suggestions for speakers, and requests for proposals of new PPP mechanisms, proposals for approaches for better coupling between private and public efforts, and opportunities for synergies with fundamental and applied plasma science.

Dr. Paz-Soldan mentioned that community responses to the solicitations are available online at <https://sites.google.com/view/fesacdpsubcommittee/home>, and include 76 whitepapers.

Dr. Ma provided details on speakers to date, which included Dr. Scott Hsu, DOE Fusion Coordinator; Mr. Andrew Holland CEO, Fusion Industry Associates; Dr. David Pace, Deputy Director, Doublet III-D (DIII-D), GA; Dr. Stan Kaye, Director of Research, National Spherical Torus Experiment-Upgrade (NSTX-U), PPPL; Professor Saskia Mordijck, President, University Fusion Association (UFA) College of William & Mary; Brian Egle, ORNL and Jesse Smith, SRNL; Paul Humrickhouse, ORNL and Tommy Fuerst, INL; and George Larsen, SRNL. Topics addressed by speakers included how the FES user facilities can advance commercial fusion applications, including models of engagement; the role of universities in the FES program; the effectiveness of current FES program elements; lithium isotope separation; and blanket, tritium, and fuel cycle. Interpretation of the charge's questions and program elements under consideration were presented.

Dr. Paz-Soldan reviewed the subcommittee's conflict of interest (COI) process, which calls for self-identification when funding has been received from an element under discussion. Open discussion is encouraged, and all members are asked to take a broad view of what is best for the overall program while working towards consensus.

The presentation should be seen as an "interim report" describing broad directions and targeted questions for FESAC. The next presentation to FESAC will contain the final subcommittee report, including findings and recommendations.

An overarching comment on findings is that the community needs to be realistic on the level of effort required to close the significant remaining S&T gaps. Current funding levels make closing gaps seem unrealistic, and bold budgets are needed to achieve the BDV. While the enacted budget matches the LRP's scenario for modest growth, defined as 2% above inflation, inflation costs, combined with the cost of launching of new programs yet to be released to the community, lead to the perception of budget stagnation.

Dr. Ma explained that the LRP predicted that the modest growth scenario would make meeting the goal of FPP readiness by the 2040s highly unlikely, require significant reductions to the U.S. tokamak program, and prevent action on important time-sensitive opportunities for U.S. leadership. The APS DPP CPP established significant support among the community to pivot

resources from existing facilities, to fund new programs and facilities, so that new facilities can be operational within ten years or less. No re-litigation of the difficult discussions and decisions of the community will be conducted by the subcommittee. The LRP will serve as a framework for all subcommittee deliberations.

Dr. Paz-Soldan explained that discussions focus on fusion materials and technology (FM&T), because it is the focus of the charge, but the science of obtaining burning plasma is an essential program. Plasma physics is not “done.” and the science program will not be terminated. FM&T consists of many low TRL mission critical elements and is therefore the next frontier for FES and the focus of several community efforts. APS DPP CPP strategic objectives (SOs) are used to define FM&T gaps. SOs include magnets, heating and current drive, and material injection; plasma-facing components (PFCs) and plasma material interactions (PMI) S&T; structural and functional materials S&T; blankets S&T, and fuel cycle; licensing, and reliability, availability, maintainability and inspectability (RAMI), and balance of plant; and the cross-cutting area of diagnostic development. The technology work included in the inertial fusion energy (IFE) BRN will also be incorporated into FM&T.

Attention and funds for FM&T programs are also necessary to realize the Blanket Component Test Facility (BCTF), the Fuel Cycle Test Facility (FCTF) and the Fusion Prototypic Neutron Source (FPNS), which were identified in the Facilities Construction Projects (FCP) report to “best serve fusion” beyond ITER.

Dr. Ma emphasized that workforce continuity is a strong consideration for the subcommittee, and may be served by PPPs and PFR, international collaborations, and upskilling into FM&T programs.

Dr. Paz-Soldan explained that PPP modalities are an additional element of the DP charge, and a dedicated effort to provide timely input is planned. The spectrum of PPP activities under consideration are PFR, the Public-Private Consortium Framework, INFUSE, and the Milestone Program.

The consensus subcommittee recommendations will be contained in the subcommittee’s report to FESAC that will be submitted to FESAC. FESAC input was solicited for the following three questions: “Are the FM&T opportunities well-captured in the community and FESAC facilities reports?”; “What are additional considerations for framing how to think about workforce continuity?”; and “Are we missing any topics for our consideration of PPP modalities?”.

Dr. White dismissed the meeting for lunch at 12:21 p.m. and reconvened at 12:58 p.m.

Discussion of the Update from the FESAC Decadal Plan Subcommittee Professor Anne White

Dr. White solicited questions for the subcommittee.

Dr. Verboncoeur explained that the use of standards is a common practice in many markets and diffuses proprietary issues as no one gains an unfair advantage, and questioned whether the subcommittee has considered developing relevant standards. **Dr. Paz-Soldan** was intrigued and agreed that the model sounds beneficial.

Dr. Thomas mentioned the demographic cliff, a forecast in which college student

numbers peak in 2025, then decayed for the subsequent decade, and solicited thoughts on the cliff's effect on workforce development. Large public universities are very worried about the cliff. **Dr. Ma** was surprised to learn about the cliff and promised that the subcommittee will address the cliff in upcoming workforce discussions. **Dr. Paz-Soldan** added that the intrinsically interesting nature of fusion could be leveraged to capture the public's imagination, which would maximize visibility, outreach, and recruiting efforts.

Dr. Reyes lamented the lack of representation from the IFE private sector on the subcommittee, and asked how bias is mitigated. **Dr. Paz-Soldan** responded that the subcommittee's considerations go beyond personal interest and the IFE public sector is engaged in the process. Whitepaper submission, as well as PPPs, as exemplified by the work of Colorado State University, are other mechanisms for private sector involvement. **Dr. Allain** emphasized that the process is designed to be open and inclusive. Every voice needs to be heard, and any group which feels ignored should contact the FES office and Dr. White.

Dr. Wilson noted that closing plasma S&T gaps, delivering an FPP, and the implications of modest growth present three conflicting priorities, and inquired how the subcommittee plans to navigate the conflict. **Dr. Paz-Soldan** explained that the charge addresses the conflict through the identification of program elements which can be deferred. However, the lack of estimates on facility costs will prevent the subcommittee from constructing a detailed budgetary roadmap.

Dr. Sowder opined that workforce continuity involves more than replacing older workers, but also competing with less risky fields like oil, gas, and aerospace to attract new workers with skillsets appropriate for achieving fusion commercialization, and questioned how such recruitment could be attained. **Dr. Paz-Soldan** noted that the charge considers both workforce continuity, and diversity in technical competency. The overlap with competing fields presents a recruitment opportunity, and recent growth in the private sector is due to acquiring talent from adjacent fields.

Dr. Verboncoeur commented that the development of standards will involve multiple organizations, which will ensure that the diversity required for fusion device complexity is established.

Dr. Kuranz noticed that the discussion of FM&T involving IFE focused solely on laser technology, and suggested the inclusion of pulse power architectures (PPA) in the final report. **Dr. Ma** agreed and mentioned that the subcommittee attempts to include all approaches and technology. **Dr. Paz-Soldan** added that the efforts of magnetic fusion energy (MFE) companies have reinvigorated PPA and energy storage infrastructure and capabilities.

Dr. Sowder informed the community of the American Society of Mechanical Engineers (ASME) standards, Section III Division 4: Fusion Energy Devices Code Rules. The standards are currently under revision and are supported by EPRI to ensure accelerated development. FESAC was encouraged to obtain a briefing on the value and purpose of codes and standards. **Dr. Paz-Soldan** requested suggestions for a speaker capable of giving the briefing.

Dr. Wilson responded to the question "Are the FM&T opportunities well-captured in the community and FESAC facilities reports?". The need for integration, allowing outputs from multiple facilities to fit into an integrated design and FPP, and the extent in which a single facility could represent exposure to multiple environments, was not adequately communicated. **Dr. Paz-Soldan** agreed and explained that it will be a necessary but challenging task to combine

the individual community reports and communicate an evaluation of overlap.

Dr. Kuranz inquired about the subcommittee’s process timeline, the date of the final report and whether the community could provide assistance. **Dr. Ma** reported that remaining tasks include additional meetings, draft reports, and speaker requests, and estimated final report completion by the end of the year. **Dr. Paz-Soldan** requested help in the form of answers to the questions posed to FESAC, and the communication of any points of contention.

Dr. Wilson responded to the question “What are additional considerations for framing how to think about workforce continuity?” The workforce will require people with knowledge spanning multiple areas. A nationalized structure, such as courses which expose Ph.D. students to a broader view of the fusion landscape, may be required. **Dr. Ma** planned to discuss Dr. Wilson’s comment with the subcommittee. A National Science Foundation (NSF) workshop on workforce development, chaired by Dr. Paz-Soldan, will release a report in the near future. **Dr. Paz-Soldan** explained that a diversity of competency is needed, and generalists have a role to play in the process. ITER’s accomplishments provide an opportunity to learn about integration.

Dr. Verboncoeur emphasized the importance of technicians to the workforce and predicted skill gaps in the transition from existing products to the manufacturing of fusion devices and infrastructure. Bridging skill gaps with design engineering is an important consideration and as prototyping begins, both skill gaps and growth should be actively tracked to inform workforce decisions. **Dr. Paz-Soldan** agreed but explained that the charge’s focus does not support the development of a comprehensive plan for workforce development. The NSF and FES program will provide important guidance. **Dr. Allain** added that learning by doing will have a big impact on program structure, which requires bridging between universities, national laboratories, and the private sector. Access to infrastructure and technology must be available at all scales and levels.

Dr. Delgado-Aparicio emphasized the existence of an apprenticeship program model that was proven successful at PPPL and is being implemented at FES. Replicating the program across DOE represents a good path forward.

Dr. White inquired if the reports mentioned during the presentation have been compiled into a reference list with uniform resource locator (URL) links. **Dr. Paz-Soldan** planned to compile a reference list and mentioned that the reports can also be found through a Google search.

Dr. Belli sought feedback on the following: workforce development, the engagement of professional societies, ensuring new and existing skills are complementary, and redefining priorities to align with the rapidly evolving landscape of the private sector. **Dr. Paz-Soldan** agreed that professional societies are assets and added that interactions are considered community engagement, which does not require DOE participation. The ultimate goal is to advance fusion energy, which requires learning and applying new skills. Programs will target the private sector, not a specific company, which simultaneously nurtures the space while adding robustness through competition.

Dr. Chacon asked how constrained budgets and dwindling numbers of professors will impact STEM education and student recruitment. In addition, the demographic cliff may trigger a demographic gap during years of reduced funding. **Dr. Paz-Soldan** noted that the demographic gap has not been discussed but can be partially alleviated through international collaboration.

The UFA has recognized the declining population of faculty, and the competitive landscape has made replacements difficult. The situation requires the community to be productive, proactive and capable of convincing university deans to invest faculty slots in fusion.

Dr. Dollar questioned how the logistical barriers to obtaining an increasing scale and diversity of stakeholders could be lowered. **Dr. Paz-Soldan** reemphasized the goal of Dr. Allain's work on building bridges and added that the subcommittee should consider how the report could advance relevant activities.

Dr. Kostadinova recommended more collaboration across programs, and the sharing of data across research and workforce development. **Dr. Ma** recalled that the LRP had a lot of emphasis on collaborations across agencies, and the subcommittee will make a similar recommendation. Fusion requires access to data at all scales, and the FIRE collaboratives' call for data repositories as a crosscutting FS&T driver is commended. **Dr. Allain** commented that a lot of planning is going into collaborations and synergies. Interactions should be thought of as working in ecosystems and be unconstrained from traditional methods.

Dr. Guiton opined that private industry must play a key role in addressing low TRL priorities in FM&T and questioned if INFUSE could facilitate the incentivization of workforce development infrastructure for a wide spectrum of career levels. There is also tension between leveraging international partnerships, which includes security considerations, and secure domestic development, which reduces the speed of progress. **Dr. Paz-Soldan** confirmed the possibility of broadening the INFUSE program. However, the FIRE collaboratives were designed to address low TRL FM&T, and private entities can apply. Private sector facilities could also participate in closing FM&T gaps, and methods to incentivize participation should be explored. International partnerships and security are challenging topics, and decisions hinge on the nations involved. **Dr. Allain** reemphasized the existence of various relevant modalities, but noted that outlining the boundaries of each partnership is key.

Dr. Esquisabel questioned if it was allowable for the subcommittee to receive the non-public, itemized cost calculations made for the LRP. Dr. Chris Holland was deeply engaged in the calculations and could provide more information on costs. **Dr. Barish** confirmed that sharing the costs is allowed. **Dr. Paz-Soldan** agreed that the information would be helpful. **Dr. Holland** planned to share information with the subcommittee and offered to answer any related questions.

Dr. Matthews commented that the demographic cliff only applies to U.S. citizens, and talent should be recruited through international collaborations. **Dr. Paz-Soldan** agreed and considers the ability to attract foreign talent a strategic advantage for the U.S.

Public Comment

Dr. Rajesh Maingi (Head of the Tokamak Experimental Science Department, PPPL) noted that the priorities set in the LRP budget scenarios were based on the imperfect knowledge of the time, which excluded the costs associated with new FM&T opportunities. The Fusion Prototypic Neutron Source (FPNS) group has done commendable work to identify cost ranges, which are unsurprisingly above LRP predictions. Before FM&T opportunities can be considered, multiple options must be moved beyond preconceptual ideas. Advancing to conceptual or engineering design stages would provide the accurate cost data required to prioritize budget decisions. **Dr. Paz-Soldan** agreed and reminded FESAC of the "B" rating in the "readiness to construct" category given to FM&T facilities in the FCP subcommittee report. An intention of

the rating was to highlight the urgent need for maturing FM&T concepts to the point of being shovel-ready.

Dr. Richard Buttery (General Atomics, Director of the DIII-D National Fusion Facility) answered the question “Are we missing any topics for our consideration of PPP modalities?” A public program can be broadly opened to private sector participation by creating an agreement by which the private sector engages in a non-proprietary way, and files no patents for technology developed with government funding. The result is a sharing of effort on technical projects and sharing expertise on common goals. DIII-D, with DOE guidance, successfully applied the model with a lightweight legal framework and currently has the participation of nine private companies. The model has potential application in national laboratories and major DOE funded projects. The joint effort of PPP requires the alignment of goals.

Dr. White dismissed the meeting for a break at 2:33 p.m. and reconvened at 3:10 p.m.

Discussion of the Update from the FESAC Decadal Plan Subcommittee (continued)

Professor Anne White

Dr. White solicited questions for the subcommittee.

Dr. Kuranz questioned Dr. Allain on the next steps for the report after approval, and the methods by which the report will be promoted. **Dr. Allain** reemphasized that the report is one part of the process to establish a national FS&T roadmap, and the collection of additional input is ongoing. **Dr. Paz-Soldan** added that after report approval, subcommittee chairs will promote the report at multiple events.

Dr. Wilson sought clarification on the length of time for FESAC to read and digest the report before a vote is required. **Dr. Barish** replied that FESAC will likely have a few days, possibly longer.

U.S. Fusion Science and Technology Roadmap Update, Dr. Jean Paul Allain, Associate Director, FES

Dr. Allain summarized the process and goals for the FS&T roadmap activity. The entire U.S. strategy is aimed at supporting a growing fusion industry. The BDV has accelerated the fusion timeline, and mechanisms to meet goals must be identified. The LRP answers the questions of “what” and “why;” current roadmap discussions are focused on the “how” – how can investments be made to build bridges, and “when” – on which timeline. The roadmap is a tool to engage experts and industry in dialogue, which will serve to define metrics and identify R&D needs and gaps. Determining the current TRLs for FM&T options is key, and there is a lack of consensus on which facilities will address which types of TRLs. The FES and public fusion programs must support all technological advantages realized. Multiple existing routes to an FPP must be integrated into a single roadmap, and science drivers identified in the LRP must be aligned with the private sector and ensure support of a future fusion power industry. The FIRE collaboratives are the first instance of a coordinated effort to define metrics and correlate activities to the advancement of specific TRLs.

A series of forums and workshops aimed at engaging public and private stakeholders, and gathering community input, will be held between calendar year 2024 quarter four (CY24-Q4) and CY25-Q2. The FS&T roadmap will be released by the end of CY25-Q2 and will be updated

annually based on input and scenarios in fusion energy research development and demonstration. FES office retreats occur at the beginning of each quarter and serve as sessions for the strategic implementation of inputs. Estimated completion dates include FESAC Facilities Construction Prioritization by CY24-Q2; FESAC Decadal Plan by early CY24-Q4; SC Prioritization and FCP integration by mid-CY24-Q4; SC FES Re-organization and budget re-structure implementation by CY25-Q1; and External support of FS&T Roadmap, and BRN, Forums and Workshops beyond CY25-Q1.

The FS&T Roadmap development plan will involve facilitator coordination with an external vendor experienced with roadmap development. The plan's major components involve developing a strategic framework and governance to ensure alignment and FACA compliance; a multi-phase input gathering process, culminating in the development of a digital roadmap platform; facilitator synthesis and integration, involving analysis of inputs, and defining metrics and systems requirements; and roadmap drafting and review which ends with a final publication and implementation schedule.

Discussion

Dr. Paz-Soldan requested a summary of the specific points in the roadmap process during which community feedback would be expected. **Dr. Allain** that explained forums would be the main channel for feedback. Forums should begin by early December.

Dr. White solicited more information on Dr. Allain's talks at the Annual Meeting of the APS DPP. **Dr. Allain** listed the sessions: a brief version of the "Vision for the Fusion Energy Sciences Program" presentation will be given at the executive committee meeting; a broader talk, including information about the roadmap, will be given at the UFA Town Hall; and remarks will be given in meetings involving high energy density science and the IFE mini-conference.

Anonymous (chat text read by Dr. White) asked for the definition of BRN. **Dr. White** defined the acronym as a Basic Research Needs workshop, commonly used in DOE to gather information. **Dr. Allain** added that BRNs are sponsored by DOE to gather expert input in specific areas and identify opportunities.

Anonymous (chat text read by Dr. White) questioned whether international partners would be involved in forums. **Dr. Allain** confirmed this and mentioned that strategic partnerships exist with like-minded nations such as the United Kingdom and Japan, which utilize coordinated committees to exchange input.

Dr. Thomas noted community challenges with project lifecycles and sought feedback in terms of the roadmap, community activities and the BDV. **Dr. Allain** explained that timelines are dictated by the varied goals of closing S&T gaps, such as de-risking a technology for the private-sector or developing the workforce. Modalities for programs which surpass the standard three-year timeframe have been under serious consideration in FES and will be addressed in the near future.

Anonymous (chat text read by Dr. White) requested the release date for a PFR FOA, along with any additional information available on program mechanics. **Dr. Allain** explained that no additional details can be shared now, but more information will be provided at the Annual Meeting of the APS DPP.

Dr. Paz-Soldan asked for dates of the upcoming BRNs. **Dr. Allain** said that no specific dates have been set, but the BRNs are considered high priority.

Dr. Vyacheslav Lukin (chat text) commented that NSF greatly appreciates the contributions of Dr. Paz-Soldan and others to the Workforce Accelerator for Fusion Energy Technology Development Conference held in May 2024.

Dr. White expressed gratitude to Dr. Allain, the DP subcommittee and all participants. FESAC plays an important role in community engagement, and any feedback towards enhancing engagement is welcome. **Dr. Allain** thanked FESAC and commended the efforts of the DP subcommittee.

Dr. White adjourned the meeting at 4:12 p.m.

Respectfully submitted on October 14, 2024,
Patrick J. Cosme, Ph.D.
Science Writer for the Oak Ridge Institute for Science and Education (ORISE)

Dr. Anne White,
FESAC Chair.
Minutes Approved Nov 25th, 2024

_____ *Anne White* _____