Invitation and Guidance for Community Input
FESAC Transformative Enabling Capabilities (TEC) Subcommittee
4/21/17

Executive Summary

The Fusion Energy Sciences Advisory Committee (FESAC) Transformative Enabling Capabilities (TEC) subcommittee welcomes the submission of white papers and talk requests (see below) that describe concepts and technologies that can bring fusion power closer to reality.

For full impact, all talk requests should be accompanied by white papers. While we recommend that all white papers be accompanied by talk requests, white papers will be considered in the absence of a companion talk. Every effort will be made to honor all talk requests responsive to the charge, subject to practical time constraints.

Background

The FESAC was recently charged "*to identify the most promising transformative enabling capabilities for the U.S. to pursue that could promote efficient advance toward fusion energy, building on burning plasma science and technology.*"

The charge lists sample focus areas including *"liquid metals, additive manufacturing, high critical-temperature superconductors, exascale computing, materials by design, machine learning and artificial intelligence, and novel measurements."* Note that these are only examples. The committee will be accepting community input on any *"promising transformative enabling capabilities"* that promote efficient advance toward fusion energy associated with the subject mater being investigate by the TEC subcommittees listed below as designated by their titles. The full charge can be found at:

https://science.energy.gov/~/media/fes/fesac/pdf/2017/Charge_Letter_FESAC_Feb_2017.pdf

Note that this activity is an assessment of (multiple) technical capabilities, and not an evaluation of confinement devices. According to the charge *"Identification of R&D that may have general impact that both includes and extends beyond"* tokamak and stellarator concepts *"is welcome. However an assessment of various types of confinement devices is not to be performed."*

The TEC subcommittee (R. Maingi, Chair, and A. Lumsdaine, Vice-Chair, full membership listed in Appendix 1) has been broken up into three sub-panels corresponding to different areas of technology application:

- Plasma Diagnostics, Actuators, and Control (lead: A. White)
- Plasma Materials Interaction (lead: J.P. Allain)
- Reactor and Balance of Plant (lead: C. Greenfield)

Community Input Meetings

In order to facilitate broad input, three meetings where the community can present to the FESAC subcommittee are planned:

- **May 30-June 1, 2017 (Washington DC area)**: Community input meeting for Plasma Diagnostics, Actuators, and Control sub-panel, and also for Reactor and Balance of Plant sub-panel; workshop starts at 9 AM on 5/30 and ends by 6 PM on 6/1.

- **June 20-22, 2017 (Chicago or Washington DC area)**: Community input meeting for Plasma-Materials Interaction sub-panel; workshop starts at 1 PM on 6/20 and ends by 6 PM on 6/22.
- **July 19-21, 2017 (PPPL, Princeton NJ)**: Final workshop for all three sub-panels; additional community input time, if necessary; workshop starts at 1 PM on 7/19 and ends by 6 PM on 7/21.

Details on the locations for these workshops will be forthcoming in the next few weeks. All presenters are strongly encouraged to attend one of the first two workshops.

White paper and talk request submission details and guidelines

White papers should be submitted to the FESAC TEC home page at the following web site: https://www.burningplasma.org/activities/?article=FESAC%20TEC%20Panel%20Public%20Info%20Home%20Page with cc to the Chair (Rajesh Maingi, rmaingi@pppl.gov) and the Vice-Chair (Arnold Lumsdaine, lumsdainea@ornl.gov) **by May 16 for the May 30 meeting, and by June 6 for the June 20 meeting**.

Talk requests with prospective titles should be submitted to rmaingi@pppl.gov and lumsdainea@ornl.gov at the earliest convenience, **but no later than May 16 for the May 30 meeting, and by June 6 for the June 20 meeting**. It is assumed that all talk requests will be followed up with white paper submissions. Any talk requests not accommodated in the first two meetings will be considered for the third meeting, July 19-21. Final talks should be submitted to the same BPO website above, using the proper radio button link, with cc to the Chair (Rajesh Maingi, rmaingi@pppl.gov) and the Vice-Chair (Arnold Lumsdaine, lumsdainea@ornl.gov). *Please use the naming convention <author>_FESAC_TEC2017_<paper or talk>.pdf.*

White papers are limited to 4 pages, and should include the components listed below. We will attempt to accommodate all requests for presentations that are responsive to our charge, subject to our time constraints. Our intention is to plan for a 15 minute talk with 15 minutes of Q/A from the FESAC subcommittee, but these may be shortened in order to provide additional presentation slots. If there are more requests than we can accommodate, even with shorter time slots, they will be accepted on a first-come, first-served basis. Please use the white paper template, linked to the FESAC TEC home page above, as a guideline, noting that not all questions will be relevant for all proposed technologies.

1. Description of the technology
2. Application of the technology for fusion energy, e.g. in a fusion power plant
3. Expected performance of the technology – what is the critical variable (or variables) that determines or controls the output of the technology?
4. Design variables – what are the parameters that can be controlled in order to optimize the performance of the technology?
5. Risks and uncertainties with the technology development and performance
6. Current maturity of the technology, using e.g. Technical Readiness Levels (TRL – see Appendix 2 for DoE TRL guidelines)
7. Required development for the technology

Initially, white papers will only be reviewed by the subcommittee and not publically available. White papers will later be posted on the web site, if permission is granted by the primary authors. Please address questions to Rajesh Maingi (rmaingi@pppl.gov) or Arnie Lumsdaine (lumsdainea@ornl.gov).

Appendix 1: FESAC TEC subcommittee membership

Rajesh Maingi (PPPL) – Chair
Arnold Lumsdaine (ORNL) – Vice-Chair
Don Rej (LANL) & S. Knowlton (Auburn – emeritus) – FESAC ex-officio members
Sam Barish (FES) – FES liaison

A. Plasma Diagnostics, Actuators, and Control (Physics and computation)

- *Anne White (MIT) – sub-panel lead*
- Luis Chacon (LANL)
- Steve Gourlay (LBNL)
- Bill Heidbrink (UCI)
- David Humphreys (GA)
- Val Izzo (UCSD)

B. Plasma Materials Interaction (Material science and engineering)

- *Jean-Paul Allain (U. Illinois) – sub-panel lead*
- Doug Crawford (ORNL)
- Oliver Schmitz (UW-M)
- Chris Spadaccini (LLNL)
- Zhehui (Jeff) Wang (LANL)
- Brian Wirth (UT-K)

C. Reactor and Balance of Plant (Mechanical, electrical, and nuclear engineering)

- *Chuck Greenfield (GA) – sub-panel lead*
- Paul Fessler (DTE Energy)
- Jerry Hughes (MIT)
- Harry McLean (LLNL)
- Jon Menard (PPPL)
- Brad Merrill (INL)

Appendix 2: DoE Technical Readiness Level Guidelines

https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-04a

Table 4. DOE Technology Readiness Level Scale

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Description
System Operations	TRL 9	Actual system operated over the full range of expected conditions.	Actual operation of the technology in its final form, under the full range of operating conditions. Examples include using the actual system with the full range of wastes.
System Commissioning	TRL8	Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with real waste in hot commissioning.
	TRL 7	Full-scale, similar (prototypical) system demonstrated in a relevant environment.	Prototype full scale system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing the prototype in the field with a range of simulants and/or real waste and cold commissioning.
Technology Demonstration	TRL 6	Engineering/pilot-scale, similar (prototypical) system validation in a relevant environment.	Representative engineering scale model or prototype system, which is well beyond the lab scale tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype with real waste and a range of simulants.
Technology Development	TRL 5	Laboratory scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity system in a simulated environment and/or with a range of real waste and simulants.
	TRL 4	Component and/or system validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of "ad hoc" hardware in a laboratory and testing with a range of simulants.
Research to Prove Feasibility	TRL 3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. Components may be tested with simulants.
	TRL 2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies.
Basic Technology Research	TRL 1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.

FESAC TEC white papers guidance and template - 4/17/17

Title for New Technology
I.M. Expert[1], C.S. Techie[2], U.R. Supporter[2]
[1]Institution #1
[2]Institution #2
Email: IMexpert@myuniversity.edu

The white paper is limited to four pages (8.5x11 inch page with 1 inch margin, no smaller than 11 point font, Times New Roman or equivalent recommended), exclusive of references. The white paper should address the points listed below. Each of these major points should be addressed, but how each point is specifically addressed will vary depending on the technology, and may not match the specific questions.

1. Technology to be assessed
2. Application of the technology (note – while the application presented may be useful for a variety of different machines, it must be applicable to a tokamak or stellarator concept).
3. Critical variable(s) – variable that determines or controls the output of the technology
    - What is the goal for transformative technology – anticipated value or range of values for critical variable that needs to be achieved?
    - What is the range that is achievable for current state of technology?
4. Design variables – parameters that can be controlled in order to optimize the critical variable. These could be qualitative.
    - Give a description of values that are currently achievable, and a description of what needs to be explored in order to achieve transformation.
5. Risks and uncertainties
    - What are the inherent constraints on the technology (such as, limits that are based on physical laws)? What are the uncertainties in the calculations of steps 3 & 4?
    - What are the engineering questions and issues (manufacturability, go / no go issues, etc.). Are there any inherent safety issues?
    - Are there institutional, regulatory, or societal obstacles to the development or use of this technology? Is there resistance to the use of this technology in the scientific community, or in the relevant industries?
6. Maturity
    - What is the current technical readiness level for the application? What progress has been made in this technology in the last 20 years and what is the projected development rate?
7. Technology development for fusion applications
    - How many simultaneous innovations are required for this technology to achieve the goal? What is required to bring this technology to TRL3 or TRL6?
    - What is the time horizon for this technology to achieve the goal for the application?
    - What resources, public and private, are currently available to develop this technology? Will developments in this technology from other sources be useful for the requirements of the application?
    - (How) are other nations, through government or private sources, developing this technology? Are there gaps in global development that represent possible opportunity for US investment?