

QUESTIONS AND ANSWERS

PLEASE REFER TO THE GENERAL FAQs SECTION OF ARPA-E'S WEBSITE ([HTTP://ARPA-E.ENERGY.GOV/?Q=FAQ/GENERAL-QUESTIONS](http://arpa-e.energy.gov/?q=faq/general-questions)) FOR ANSWERS TO MANY GENERAL QUESTIONS ABOUT ARPA-E AND ARPA-E'S FUNDING OPPORTUNITY ANNOUNCEMENTS. ADDITIONAL QUESTIONS SPECIFIC TO THIS FOA ONLY ARE INCLUDED BELOW. PLEASE REVIEW ALL EXISTING GENERAL FAQs AND FOA-SPECIFIC QUESTIONS BEFORE SUBMITTING NEW QUESTIONS TO ARPA-E.

I. Concept Paper Phase Questions:

Q1. DO REFERENCES COUNT TOWARDS CONCEPT PAPER 5 PAGE LIMIT?

ANSWER: Please refer to section IV.C.1.c ("Content and Form of Concept Papers") of the FOA.

Q2. OUR GROUP AT [REDACTED] HAS BEEN APPROACHED BY MULTIPLE INSTITUTIONS THAT WANT TO SUBMIT PROPOSALS IN RESPONSE TO THE CREATING HARDENED AND DURABLE FUSION FIRST WALL

INCORPORATING CENTRALIZED KNOWLEDGE (CHADWICK) FOA, DE-FOA-0003240. OUR ROLE WOULD ESSENTIALLY BE SIMILAR IN ALL PROPOSALS - NAMELY TO PROVIDE FOR PLASMA AND DISPLACEMENT DAMAGE IRRADIATION TO PROMISING FUSION FIRST WALL CANDIDATE MATERIALS. READING THROUGH THE FOA IT WOULD THEREFORE SEEM THAT WE COULD SUBMIT UNDER CATEGORY C OF THE FOA, AND PROPOSE FUNDING THAT WOULD ALLOW US TO SUPPORT ALL OF THE GROUPS THAT WERE CHOSEN FOR FUNDING IN THE CHADWICK FOA. HOWEVER, THE PARTNERS THAT HAVE APPROACHED US ASK THAT WE SUBMIT AS PART OF THEIR PROPOSALS IN CATEGORY A.

BEFORE DECIDING HOW TO PROCEED, I WANTED TO ASK: DOES ARPA-E HAVE ANY GUIDANCE ON HOW YOU WOULD WISH TO SEE A FACILITY LIKE OURS PARTICIPATE IN THE CHADWICK PROGRAM?

ANSWER: Please refer to Section I.D.4 of the FOA. ARPA-E will not pre-assess the structure and makeup of proposed project teams.

Q3. I COULD NOT FIND THE ANSWER TO THIS QUESTION IN THE ONLINE FAQ. FOR THE CHADWICK FOA: ARE CU ALLOYS AS PART OF THE FIRST WALL STRUCTURE, OF INTEREST TO THIS FOA UNDER TOPIC AREA A (OR IS THIS TOPIC AREA EXCLUSIVELY INTERESTED IN W ALLOYS)?

ANSWER: Cu alloys are of interest as a structural component in Category B if sufficient justification is provided on how the new alloy can replace RAFM as a structural component of the first wall and will be analyzed for activation by Category C teams.



Q4. CONCERNING THE CONCEPT PAPERS:

ARE THERE ESTIMATES FOR THE SIZE OF THE GRANTS, THEIR DURATION, AND FOR THE MATCHING FUNDS REQUIRED?

ANSWER: Please refer to the DE-FOA-0003240 CHADWICK funding opportunity announcement sections II.A Award Overview and III.B. Cost Sharing.

Q5. CAN YOU CLARIFY A COUPLE OF POINTS? THE FOA STATES THAT LIQUID METALS ARE WITHIN SCOPE. AND SUCCESSFUL LIQUID PFCS COULD CERTAINLY BE TRANSFORMATIONAL. HOWEVER, IT SEEMS TO US THAT THE FOA STATES THAT CERTAIN METRICS MUST BE MET, EVEN THOUGH THEY AREN'T NECESSARY AND IN FACT CAN'T BE MET BY ANY LIQUID METAL. EARLIER DISCUSSION REGARDING THIS PROGRAM SUGGESTED THAT LIQUID METAL SOLUTIONS WOULD BE CONSIDERED 'IN SCOPE' AS LONG AS THEY SATISFIED SOME SORT OF 'EQUIVALENT' METRIC. COULD YOU CLARIFY THIS?

LET'S CONSIDER, SPECIFICALLY, THE THREE BASELINE METRICS THAT (IT SEEMS TO US) FOA STATES MUST BE MET. WE ARE UNCLEAR HOW TO INTERPRET THEM WHEN SUBMITTING A PROPOSAL ON LIQUID METAL MATERIALS FOR PFCS:

- 1) LIQUID PFCS INEVITABLY HAVE LOWER THERMAL CONDUCTIVITY THAN THE SPECIFIED 170 W/MK, BUT SINCE THEY ARE MUCH THINNER, THE OPERATING TEMPERATURE IS QUITE ACCEPTABLE, AND HIGH HEAT FLUXES CAN BE ACCEPTED. AS AN EXAMPLE, CONSIDER THE (CONSIDERABLE) EU DEMO PROGRAM ON TIN LIQUID DIVERTOR PFCS, WITH A HEAT SINK BEHIND TO REMOVE HEAT. TIN HAS CONDUCTIVITY ONLY ~ 40 W/MK, BUT SINCE THE LIQUID METAL IS ONLY ~ 2MM THICK, THIS STILL ALLOWS > 20 MW/M2 IN THEIR DESIGNS, WITH A QUITE CONVENTIONAL HEAT SINK BEHIND THE TIN PFC. IN FACT, NO LM THAT IS SUITABLE FOR A PFC CAN APPROACH THE 170 W/MK VALUE, BUT LIKE THE TIN CASE IN THE EU DESIGN, THEY CAN POTENTIALLY HANDLE HEAT FLUXES FAR IN EXCESS OF 10 MW/M2.**

- 2) PLASMA EROSION: ALL LMS HAVE SPUTTERING HIGHER THAN THE SPECIFICATION, BUT SINCE THE PFC IS REPLACED, IT DOESN'T AFFECT PFC LIFETIME. FURTHERMORE, OUR PROPOSAL IS TO DEVELOP LMS WITH ONLY LOW Z SPUTTERING, SO IMPACT ON THE PLASMA IS MINIMAL EVEN WITH A MUCH HIGHER EROSION THAN THE VALUE SPECIFIED IN THE FOA (3.4 MICRO-METER/HR)- A VALUE PERTINENT FOR VERY HIGH Z TUNGSTEN.**

3) TRITIUM SOLUBILITY: AGAIN USING THE EU TIN PFC PROGRAM AS AN EXAMPLE, THE T SOLUBILITY OF TIN IS ~ 3 ORDERS OF MAGNITUDE HIGHER THAN THE SOLUBILITY IN THE FOA SPECIFICATION, BUT THE EU DOESN'T FIND THIS TO BE AN ISSUE AT ALL, BECAUSE OF THE EXTREMELY LOW VOLUME OF TIN. (TRITIUM INVENTORY IN THE ENTIRE TIN PFC IS ROUGHLY AS MUCH AS IN THE CORE PLASMA IN OPERATION.) FURTHERMORE LMS ALLOW SLOW RECIRCULATION WITH TRITIUM REMOVAL, SO T DOESN'T BUILD-UP. ADEQUATE T REMOVAL WOULD BE ENORMOUSLY EASIER THAN THE COMPARABLE TECHNOLOGY OF REMOVING T FROM A BREEDING BLANKET OF LM BEACUSE OF THE VERY LOW VOLUME AND RECIRCULATION RATE OF THE LM PFC (THE ENTIRE EU DIVERTOR LM PFC VOLUME IS ~ 1/10 CUBIC METER).

SO EQUIVALENT PERFORMANCE IS ATTAINABLE WITH LM PFCS, IN THE SENSE OF HIGH HEAT FLUX CAPABILITY, LOW TRITIUM INVENTORY AND EROSION THAT ALLOWS OPERATION FOR MANY YEARS WITHOUT DEGRADING THE CORE PLASMA. THE LM WOULD ALSO OFFER MAJOR ADVANTAGES IN TRANSIENT RESILIENCE AND AVOIDING HIGH Z "UFO" DISRUPTIONS. AND WITH AN APPROPRIATE HEAT SINK THEY MIGHT BE ABLE TO HANDLE EVEN HIGHER HEAT FLUX THAN SOLIDS, DESPITE THEIR LOWER THERMAL CONDUCTIVITY, BECAUSE THEY CAN BE MUCH THINNER THAN SOLID PFCS, AND LIQUIDS AREN'T SUBJECT TO MECHANICAL STRESS DUE TO THERMAL GRADIENTS.

BUT THE NOMINAL "BASELINE" VALUES SPECIFIED IN THE FOA CANNOT BE MET, BY A WIDE MARGIN, FOR PROBABLY ANY LM USEFUL FOR A PFC. WE'RE JUST VERIFYING THAT WE WILL BE ABLE TO PROCEED WITH A PROPOSAL ALONG THE LINES OF 'EQUIVALENT PERFORMANCE'. OTHERWISE, NO PROPOSAL FOR LIQUID PFCS WOULD BE POSSIBLE, I BELIEVE, FOR ANY GROUP.

ANSWER: DE-FOA-0003240 CHADWICK is a material discovery program and proposed materials need to meet the requirement of novel composition, microstructure, or macrostructure. Section I.D. of the FOA states the category specific design constraints of thermal conductivity, plasma erosion and tritium solubility are provided to ensure any new materials developed will maintain integrated performance compared to current baseline. An inability to meet one of the constraints may not necessarily disqualify a material product from being used in the first wall of new fusion concepts but the tradeoffs must be addressed in the submission. If the Applicant proposes a material solution that requires changes in current fusion system design and deviates from existing baseline constraints, detailed technical justification and letters of support from industry are expected to be provided as reasonable assurance that equivalent performance metrics proposed are adequate and appropriate.

Q6. THE ARPA-E FOA CHADWICK SEEKS FOR INNOVATIONS IN THE FUSION REACTOR FIRST WALL.

THE ANNOUNCEMENT DOCUMENT LISTS VERY SPECIFIC LOAD CONDITIONS FOR HEAT LOADS (10 MW/M²), EROSION RATES, ION FLUXES 10²² ION/M² S AT 650 DEGREE C. THEY ALSO SUGGEST TARGET VALUES FOR IMPROVEMENTS. THE ACCEPTABLE BASELINE VALUES REFER TO LITERATURE.

IT IS MY EXPERIENCE THAT THE LOAD CONDITIONS DEPEND ON THE REACTOR DESIGN. 10MW/M² SEEMS EXCESSIVELY HIGH FOR A REACTOR FIRST WALL (PERHAPS DIVERTOR, BUT NOT FIRST WALL). WITH A PROPER DESIGN ION FLUXES CAN BE MINIMIZED TO THE FIRST WALL. THE QUESTION IS, CAN A PROPOSAL INCLUDE DESIGN CHOICES LEADING TO ALTERNATIVE LOADING CONDITIONS AND HENCE DIFFERENT CONSTRAINTS AS WRITTEN IN TABLE 2, RESULTING IN ALTERNATIVE MATERIAL CHOICES?

ANSWER: See answer to question 5.

Q7. I HAVE A QUESTION RELATED TO THE ARPA-A CALL "CREATING HARDENED AND DURABLE FUSION FIRST WALL INCORPORATING CENTRALIZED KNOWLEDGE (CHADWICK) ANNOUNCEMENT TYPE: INITIAL ANNOUNCEMENT FUNDING OPPORTUNITY NO. DE-FOA-0003240 CFDA NUMBER 81.135".

IS DEVELOPMENT OF FIRST WALL SYSTEMS WITH LIQUID METAL MATERIALS SUCH AS LITHIUM, TIN-LITHIUM, TIN, ON THE PLASMA FACING COMPONENT WITHIN SCOPE OF THIS CALL?

ANSWER: See answer to question 5

Q8. ---REDACTED---. IN THE PAST FOR DOE AWARDS, WE HAVE PROVIDED COST SHARE IN-KIND SUCH AS LAB EQUIPMENT, BACKGROUND TECHNOLOGY OR OTHER RESOURCES. WOULD ONE OF THOSE BE CONSIDERED ACCEPTABLE COST SHARE?

ONE COMMERCIAL PARTNER ASKED HOW IP WOULD BE DIVIDED AND WHETHER INFO SUBMITTED WOULD BECOME OPEN SOURCE.

ANSWER: 1. Please refer to the DE-FOA-0003240 CHADWICK funding opportunity announcement section III. B ("Cost Sharing").

2. Please refer to the answer to question 2.20 in the general questions section of the ARPA-E website titled "General Questions on Funding Opportunities". Please also refer to DE-FOA-0003240 CHADWICK funding opportunity announcement Section VIII.A-C.

Q9. I AM SUBMITTING THESE QUESTIONS REGARDING THE SUBJECT FOA IN ACCORDANCE WITH THE FOA INSTRUCTION.

QUESTIONS:

- 1. INFORMATION REGARDING "FUNDING REQUESTED" IS TO BE INDICATED IN THE CONCEPT PAPER TITLE BLOCK. HOW WILL ARPA-E USE THE DATA PROVIDED REGARDING "FUNDED REQUESTED"? IS THIS TREATED AS A ROM AND VARIATION IN THE FINAL PROPOSAL IS ACCEPTABLE?**
- 2. SUB-RECIPIENTS: CAN ARPA-E FUND TEAMING PARTNERS UNDER AN OTA BE TREATED AS SUB-RECIPIENTS, OR WILL PRIME AWARDEE FUND ALL OF THE TEAMING PARTNERS THEMSELVES VIA SUBCONTRACT OR OTHER ARRANGEMENT?**
- 3. PAGE LIMIT: DOES THE 5 PAGE LIMIT FOR THE CONCEPT PAPER ALSO APPLY TO A PROGRAM COMPRISING BOTH CATEGORY A AND CATEGORY B COMPONENTS? THE PAGE LIMIT MAY CONSTRAIN CLEAR DESCRIPTION OF SUCH MORE COMPLEX PROGRAM.**

ANSWER: 1. Please refer to the answer to question 2.9 in the general questions section of the ARPA-E website titled "General Questions on Funding Opportunities".

2. Please refer to the DE-FOA-0003240 CHADWICK funding opportunity announcement section I. D. 4("Category and Team Logistics")."
3. In order to maintain the "objective process" required by federal regulation at 2 CFR 200.205 ("Federal awarding agency review of merit proposals"), concept papers should be submitted with the content and form described in the FOA. For more information on content and form of concept papers, please see DE-FOA-0003240 CHADWICK funding opportunity announcement section IV. C ("Content and Form of Concept Papers")

Q10. I AM THE LEAD PI ASSEMBLING A TEAM TO RESPOND TO THE CHADWICK CALL. --- REDACTED--- IS OUR PRIVATE FUSION COMPANY PARTNER, AND WE PLAN TO USE DIII-D TO CHARACTERIZE SPECIFICALLY THE PLASMA-MATERIAL INTERACTION IN ALLOY LIBRARIES THAT WE DEVELOP. ---REDACTED--- MENTIONED THAT WE NEED TO WRITE TO THIS EMAIL ADDRESS TO RECEIVE GUIDANCE ON HOW TO INCLUDE DIII-D IN OUR PROPOSAL. I WOULD APPRECIATE YOUR GUIDANCE ON THIS MATTER.

ANSWER: Please refer to the DE-FOA-0003240 CHADWICK funding opportunity announcement section III.A.2 ("Eligibility Information")

Q11. I AM INTERESTED IN PUTTING IN A CONCEPT PAPER TO CATEGORY C WITH A UNIVERSITY. MY UNDERSTANDING WHEN READING THE CALL IS THAT A CONCEPT PAPER FOR CATEGORY C IS FOCUSED MORE ON THE CAPABILITIES AND SKILLS OF THE INDIVIDUAL ENTITIES MAKING UP THE CONCEPT PAPER TEAM? SO, FOR EXAMPLE, THE PAPER WOULD BE MORE FOCUSED ON INFRASTRUCTURE THAT CAN SUPPORT DATA MANAGEMENT AND COMPUTATIONAL WORK AND SKILLS SUCH AS NEUTRON IRRADIATION ANALYSIS AND LIFE CYCLE ASSESSMENT AND TECHNO-ECONOMIC ANALYSIS EXPERTISE?

IS MY UNDERSTANDING OF THE CATEGORY C CONCEPT PAPER SUBMISSION GUIDELINES CORRECT? WOULD THERE BE ANY OTHER RECOMMENDATIONS ON WHAT ARPA-E IS EXPECTING TO BE INCLUDED IN THE CATEGORY C CONCEPT PAPER?

ANSWER: Yes. Refer to Section 1.D.4 for Category C team responsibilities.

Q12. I HAVE A QUESTION REGARDING THIS FOA. PAGE 24 OF THE DOCUMENT (PAGE 28 OF THE PDF FILE) STATES THAT THE PRIME RECIPIENT MUST PROVIDE 20% COST SHARE. UNDER THE REDUCED COST SHARE REQUIREMENTS THERE IS THE FOLLOWING PARAGRAPH PERTAINING TO FFDRC'S

"PROJECT TEAMS WHERE DOMESTIC EDUCATIONAL INSTITUTIONS, DOMESTIC NONPROFITS, SMALL BUSINESSES, AND/OR FFRDCS PERFORM GREATER THAN OR EQUAL TO 80% OF THE TOTAL WORK UNDER THE FUNDING AGREEMENT (AS MEASURED BY THE TOTAL PROJECT COST) ARE REQUIRED TO PROVIDE AT LEAST 10% OF THE TOTAL PROJECT COST AS COST SHARE. HOWEVER, ANY ENTITY (SUCH AS A LARGE BUSINESS) RECEIVING PATENT RIGHTS UNDER A CLASS WAIVER, OR OTHER PATENT WAIVER, THAT IS PART OF A PROJECT TEAM RECEIVING THIS REDUCTION MUST CONTINUE TO MEET THE STATUTORY MINIMUM COST SHARE REQUIREMENT (20%) FOR ITS PORTION OF THE TOTAL PROJECT COST."

WHICH I UNDERSTAND TO MEAN THAT FFDRC DOING >80% OF THE WORK AS THE PRIME NEEDS TO PROVIDE 10% COST SHARE. CAN YOU PLEASE CONFIRM OR CLARIFY? AS AN FFDRC ORNL CANNOT PROVIDE COST SHARE.

ANSWER: Please refer to the answers to questions 3.6 and 4.16 in the general questions section of the ARPA-E website.

Q13. I AM CONTACTING YOU TO INQUIRE ABOUT THE CHADWICK FOA. HERE ARE A FEW QUESTIONS FOR YOU.

- 1. CAN I (PI) DIRECTLY SUBMIT A CONCEPT PAPER, NOT THROUGH A GRANT ADMINISTRATOR OF OUR INSTITUTION?**
- 2. SHOULD I INCLUDE THE ESTIMATED BUDGET IN THE CONCEPT PAPER?**

ANSWER: 1. Please refer to the answer to question 3.2 in the general question section of the ARPA-E website.

2. Please refer to section IV.C.1. (“Content and Form of Concept Papers”) and section V.A.1. (“Criteria for Concept Papers”) of the FOA.

Q14. FOR EACH PI OR CO-PI OF A CONCEPT PAPER FOR THE CHADWICK CALL, COULD HE/SHE BE INVOLVED WITH OTHER CONCEPT PAPERS?

ANSWER: Please refer to section III.C.4. (“Limitation on Number of Submissions”) of the FOA. Also refer to the answer to question 6.13 in the General Questions section of the ARPA-E website.

Q15. ARE FOREIGN NATIONALS (NOT US CITIZENS OR PERMANENT RESIDENTS) WORKING AT US UNIVERSITIES ELIGIBLE TO APPLY FOR THE CHADWICK GRANT APPLICATION?

ANSWER: Please refer to section III.A.3. (“Foreign Entities”) of the FOA.

Q16. WE HAVE THE FOLLOWING QUESTIONS REGARDING THE CHADWICK FOA:

- 1. CAN WE ADD A PARTNER TO THE TEAM BETWEEN THE CONCEPT PAPER AND THE FULL APPLICATION?**
- 2. OUR TEAM INCLUDES A FOREIGN INSTITUTION (**REDACTED**), AND WE HAVE SOME FINANCIAL QUESTIONS. IT IS SPECIFIED IN THE FOA THAT ONE REQUIREMENT FOR AN ORGANIZATION IS TO BE ABLE TO ACCEPT "FINANCIAL ASSISTANCE". IS THIS DIFFERENT THAN A GRANT? ALSO, DOES DOE HAVE A RULE FOR ACCEPTABLE RATE OF OVERHEADS FOR FOREIGN INSTITUTIONS? **REDACTED** THEIR OVERHEADS ARE ROUGHLY SIMILAR TO THE ONES FROM .**

ANSWER: 1. Please refer to the answer to question 7.11 in the General Questions section of the ARPA-E website. For a definition of “federal financial assistance” please refer to the “Definitions” section of the Uniform Grant Guidance at 2 CFR 200.1.

2. Please refer to the answer to question 4.11 in the General Questions section of the ARPA-E website.

Q17. MY NAME IS ***REDACTED*** AND I AM AN ASSISTANT PROFESSOR OF NUCLEAR ENGINEERING AT***REDACTED***. I HAVE A QUESTION REGARDING THE CHADWICK FOA AND WOULD GREATLY APPRECIATE YOUR ASSISTANCE IN CLARIFYING IT.

WITHIN TABLE 2 OF THE FOA DOCUMENTATION, THE CRITERIA FOR ACCEPTED TRITIUM DIFFUSIVITY IS OUTLINED AS GREATER THAN $1.6E-8 \text{ M}^2/\text{S}$ AT 650°C , WITH A GOAL TO ACHIEVE A TWOFOLD IMPROVEMENT, SPECIFICALLY GREATER THAN $3.2E-8 \text{ M}^2/\text{S}$ AT THE SAME TEMPERATURE. THIS SPECIFICATION RAISES A QUERY FROM A TRITIUM RETENTION STANDPOINT, WHERE A LOWER TRITIUM DIFFUSIVITY WOULD SEEMINGLY BE PREFERABLE TO MINIMIZE TRITIUM RELEASE INTO THE ENVIRONMENT. COULD YOU KINDLY ELUCIDATE THE UNDERLYING PHYSICAL REASONING FOR ESTABLISHING A HIGHER DIFFUSIVITY TARGET IN THIS CONTEXT?

ANSWER: Tritium is a fuel for fusion power plant and should not be trapped inside the first wall. There will be other fusion plant systems responsible for tritium removal and minimize release that are outside the scope of this program.