U.S. Department of Energy

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs

Topics

FY 2015
Phase I
Release 2

Version 5, December 15, 2014

Participating DOE Research Programs

- Office of Defense Nuclear Nonproliferation
- Office of Electricity Delivery and Energy Reliability
- Office of Energy Efficiency and Renewable Energy
- Office of Fossil Energy
- Office of Fusion Energy Sciences
- Office of High Energy Physics
- Office of Nuclear Energy

Schedule

Event	Dates
Topics Released:	Monday, October 27, 2014
Funding Opportunity Announcement Issued:	Monday, November 24, 2014
Letter of Intent Due Date:	Monday, December 15, 2014
Application Due Date:	Tuesday, February 03, 2015
Award Notification Date:	Late April 2015*
Start of Grant Budget Period:	Early June 2015*

* Dates Subject to Change

Table of Changes		
Version	Date	Change
Ver. 1	October 27, 2014	Original
Ver. 2	October 29, 2014	Point of Contact added for Topic 1, subtopic e.
Ver. 3	November 3, 2014	Correction made in Topic 10b: 480 kVac output to 480 Vac output.
Ver. 4	November 7, 2014	References 3-6 added to topic 11d
Ver. 5	December 15, 2014	Revision to Topic 11d: Performance targets include a conversion efficiency between 20% to 30%

TECHNOLOGY TRANSFER OPPORTUNITIES

Selected topic and subtopics contained in this document are designated as **Technology Transfer Opportunities** (TTOs). The questions and answers below will assist you in understanding how TTO topics and subtopics differ from our regular topics.

What is a Technology Transfer Opportunity?
A Technology Transfer Opportunity (TTO) is an opportunity to leverage technology that has been developed at a university or DOE National Laboratory. Each TTO will be described in a particular subtopic and additional information may be obtained by using the link in the subtopic to the university or National Lab that has developed the technology. Typically the technology was developed with DOE funding of either basic or applied research and is available for transfer to the private sector. The level of technology maturity will vary and applicants are encouraged to contact the appropriate university or Laboratory prior to submitting an application.

How would I draft an appropriate project description for a TTO?
For Phase I, you would write a project plan that describes the research or development that you would perform to establish the feasibility of the TTO for a commercial application. The major difference from a regular subtopic is that you will be able to leverage the prior R&D carried out by the university or National Lab and your project plan should reflect this.

Am I required to show I have a subaward with the university or National Lab that developed the TTO in my grant application?
No. Your project plan should reflect the most fruitful path forward for developing the technology. In some cases, leveraging expertise or facilities of a university or National Lab via a subaward may help to accelerate the research or development effort. In those cases, the small business may wish to negotiate with the university or National Lab to become a subawardee on the application.

Is the university or National Lab required to become a subawardee if requested by the applicant?
No. Collaborations with universities or National Labs must be negotiated between the applicant small business and the research organization. The ability of a university or National Lab to act as a subcontractor may be affected by existing or anticipated commitments of the research staff and its facilities.

Are there patents associated with the TTO?
The TTO will be associated with one or in some cases multiple patent applications or issued patents.

If selected for award, what rights will I receive to the technology?
Those selected for award under a TTO subtopic, will be assigned rights to perform research and development of the technology during their Phase I or Phase II grants. Please note that these are NOT commercial rights which allow you to license, manufacture, or sell, but only rights to perform research and development.

In addition, an awardee will be provided, at the start of its Phase I grant, with a no-cost, six month option to license the technology. It will be the responsibility of the small business to demonstrate adequate progress towards commercialization and negotiate an extension to the option or convert the option to a license. A copy of an option agreement template will be available at the university or National Lab which owns the TTO.

How many awards will be made to a TTO subtopic?
Initially we anticipate making a maximum of one award per TTO subtopic. This will insure that an awardee is able to sign an option agreement that includes exclusive rights in its intended field of use. If we receive applications to a TTO that address different fields of use, it is possible that more than one award will be made per TTO.

How will applying for an SBIR or STTR grant associated with a TTO benefit me?
By leveraging prior research and patents from a National Lab you will have a significant “head start” on bringing a new technology to market. To make greatest use of this advantage it will help for you to have prior knowledge of the application or market for the TTO.

Is the review and selection process for TTO topics different from other topics?
No. Your application will undergo the same review and selection process as other applications.

PROGRAM AREA OVERVIEW: OFFICE OF DEFENSE NUCLEAR NONPROLIFERATION

The Defense Nuclear Nonproliferation (DNN) mission is to provide policy and technical leadership to limit or prevent the spread of materials, technology, and expertise relating to weapons of mass destruction; advance the technologies to detect the proliferation of weapons of mass destruction worldwide; and eliminate or secure inventories of surplus materials and infrastructure usable for nuclear weapons. It is the organization within the Department of Energy's National Nuclear Security Administration (NNSA) responsible for preventing the spread of materials, technology, and expertise relating to weapons of mass destruction (WMD).

Within DNN, the Research and Development (R&D) program office sponsors long-term development of new and novel technology reduces the threat to national security posed by nuclear weapons proliferation and detonation or the illicit trafficking of nuclear materials. Using the unique facilities and scientific skills of NNSA and DOE national laboratories and plants, in partnership with industry and academia, the program conducts research and development that supports nonproliferation mission requirements necessary to close technology gaps identified through close interaction with NNSA and other U.S government agencies and programs. This program meets unique challenges and plays an important role in the federal government by driving basic science discoveries and developing new technologies applicable to nonproliferation, homeland security, and national security needs. DNN R&D has two sub-Offices: Proliferation Detection and Nuclear Detonation Detection.

The Proliferation Detection Office (PD) advances basic and applied technologies for the nonproliferation community. PD develops the tools, technologies, techniques, and expertise for the identification, location, and analysis of the facilities, materials, and processes of undeclared and proliferant nuclear weapons programs and to prevent the diversion of special nuclear materials, including use by terrorists.

The Nuclear Detonation Detection Office (NDD) builds the nation's operational sensors that monitor the entire planet from space to detect and report surface, atmospheric, or space nuclear detonations; and produces and updates the regional geophysical datasets enabling operation of the nation's ground-based seismic monitoring networks to detect and report underground detonations. NDD conducts research and development on nuclear detonation forensics, improvements in satellite operational systems to meet future requirements and size and weight constraints, and in radionuclide sampling techniques for detection of worldwide nuclear detonations.

1. NUCLEAR WEAPONS DEVELOPMENT AND MATERIAL PRODUCTION DETECTION

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) has a research objective to:
Develop remote sensing technology to support detection and characterization of signatures or activities related nuclear proliferation.

Research projects encompass a wide variety of potential capabilities to detect signatures associated with the development of nuclear weapons including sensor development, image processing, and digital signal processing techniques for characterization of observed phenomena.

DNN R&D holds an annual University Information Technical Interchange (UITI) program review meeting where University and SBIR/STTR projects are presented to the program managers. All awardees are required to attend and present their progress at this meeting each year.

Grant applications are sought only in the following subtopics:

a. Development and Validation of a Polarized 3D Atmospheric Radiation Model

Increasing signature contrast in both the solar and thermal spectral regions, obtained from the Stokes vector data, provides advanced avenues for improving material identification. Analysis of these data requires polarization signature models that incorporate the effects of absorption, emission and scattering in the 3D atmospheric and terrain environment. Although high fidelity, scalar, 1D atmospheric radiative transfer models are readily available [Berk et al. 2006], few 1D polarization models [MODTRAN-P, vector-6S] have been developed. These 1D polarized models have significant limitations in spectral coverage, computational speed, optical polarization databases, and/or physics fidelity. There are currently no available models that treat all the polarized spectral signatures of key 3D scene elements such as clouds, plumes, topographic backgrounds, and man-made objects in a self-consistent, unified approach.

Research is sought to develop a validated 3D polarized atmospheric radiation transport model. The Phase I effort should focus (1) on assessing current 1D capabilities and available polarization databases, (2) on formulating approaches for upgrades to the 1D models for a fully polarized implementation in Phase II, (3) on designing a 3D polarization model, and (4) on planning validation field measurements in collaboration with a DOE lab. A validated 3D polarized radiance model that incorporates the effects of water clouds, plumes, natural terrain and turbid water backgrounds, and both man-made and natural materials will be developed in Phase II. The new model will be tested against the existing 1D models and validated against DOE field measurements.

Questions – contact: Victoria Franques, victoria.franques@nnsa.doe.gov

b. Remote Detection of Extremely Small Vibration

In order to further the goal of nuclear nonproliferation, it is important to be able to detect remotely signs of clandestine nuclear activities, such as, but not limited to, operation of dynamic machinery in hidden, subterranean facilities. In principle, such an operation can be identified by detection of small vibrations at characteristic frequencies. However, these signals are expected to be extremely small if the machinery is hidden deep under a mountain, for example. Conventional vibration detectors have typical sensitivities of 1 micro-g per root Hertz (where g is the acceleration due to Earth's gravity), and would not be able to detect these signals from a significant distance. Recent developments have shown that new types of detectors, such as those based on the use of the fast-light effect induced by anomalous dispersion, can enhance the sensitivity to vibration by nearly six orders of magnitude. Devices based on these technologies may be configured for ultrasensitive sensing of many effects, including rotation and vibration. Therefore, grant applications are sought for the development of technology for remote detection of extremely small vibration signatures, with a sensitivity of at least 1 pico-g per root Hertz, representing a six orders of magnitude enhancement over the typical capability of current technologies. A proposed vibrometer must be able to detect vibrations in three orthogonal directions, should also be extremely compact, have a high dynamic range, be very robust against environmental disturbances, and consume very low power.

Questions – contact: Victoria Franques, victoria.franques@nnsa.doe.gov

c. Temperature-Emissivity-Separation (TES) with Combined Fluid Flow – Hyperspectral Radiation Simulations

Temperature-emissivity-separation (TES)[1, 2, 3] for a target object relies on accurate data for computation of thermal radiation fluxes being emitted by the sky and by adjacent objects. In cluttered scenes, TES is made more difficult by the contributions of adjacent objects to the thermal radiation received by a target object, which reduces the target object's characteristic spectral features.

Simulations of the target object using hydrodynamic - hyperspectral simulators are an alternative to traditional TES. The combined hydrodynamic - hyperspectral simulations require best available scene geometry, meteorology and target characteristics. Target temperature and material could be determined by running a series of simulations with different target spectra until best matches between measured and simulated apparent target temperature and spectra are found.

Proposals are solicited to assess the ability of combined hydrodynamic – hyperspectral simulators (HHS) to reproduce target object temperatures and spectra in geometrically complex environments. Part of the project would be blind tests of the ability of the HHS to identify target materials, using hyperspectral images of target objects and other data collected by Department of Energy remote sensing program. One or more DOE national laboratories would supply the successful applicant with the necessary experimental data for model validation. The collaborating DOE laboratory would evaluate the successful applicant's comparisons of simulation to measurement, material identification and the improvement afforded by the HHS relative to codes[4] that do not include realistic fluid flow to drive convective heat transfer in the simulations.

Questions – contact: Victoria Franques, victoria.franques@nnsa.doe.gov

d. Automated Feature Extraction from Seismo-Acoustic Data

Persistent long-term monitoring of process facilities using seismo-acoustic systems are characterized by collecting large quantities of data, particularly for sensor system consisting of multiple arrays with sampling rates of multiple 1000s of samples per second. These data must then be manually analyzed to identify and extract features that could be indicative of different processes. Research is sought to develop a capability to automatically extract features of interest (e.g., periodic impulsive and tonal events, transient tonal events, etc.) from these data, which can then be further analyzed by human analysts. In Phase I, the performer will demonstrate the ability to correlate signature features with processes of interest using collected data sets. In Phase II, the performer will develop the automated feature extraction capability and demonstrate that capability using collected data sets. The final system will improve the ability for analysts to correlate signature features with processes of interest.

Questions – contact: Steve Frederiksen, steven.frederiksen@nnsa.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this Topic.

Questions – contact: Victoria Franques, victoria.franques@nnsa.doe.gov

References:

Subtopic a

1. A. Berk, et al. (2006). *MODTRAN5: 2006 Update*. SPIE, Volume 6233. p. 62331F. Available at http://spie.org/Publications/Proceedings/Paper/10.1117/12.665077

2. J. Craven-Jones, et al. (2011). *Infrared Hyperspectral Imaging Polarimeter Using Birefringent Prisms*. Applied Optics. Volume 50. Issue 8. pp. 1170-1185. http://fp.optics.arizona.edu/detlab/Articles-Publications/2011-Craven-Infrared-hyperspectral-imaging-polarimeter-using-birefringent-prisms.pdf

3. S.Y. Kotchenova, et al. (2006). Validation of a Vector Version of the 6S Radiative Transfer Code for Atmospheric Correction of Satellite Data, Part I: Path Radiance. Applied Optics. Volume 45. pp 6762–6774. http://6s.ltdri.org/6S_code2_thiner_stuff/Kotchenova_et_al_2006.pdf

4. S.Y. Kotchenova, et al. (2007). *Validation of a Vector Version of the 6S Radiative Transfer Code for Atmospheric Correction of Satellite Data, Part II: Homogeneous Lambertian and Anisotropic Surfaces*. Applied Optics. Volume 44. pp 4455–4464. Available at http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-46-20-4455

5. N.J. Pust & J.A. Shaw. (2011). *Comparison of Skylight Polarization Measurements and MODTRAN-P Calculations*. Journal of Applied Remote Sensing. Volume 5. Issue 053529. pp. 1-16. Available at http://remotesensing.spiedigitallibrary.org/article.aspx?articleid=1182393

6. R. Sundberg, S. Richtsmeier & R. Haren. (2010). *Monte Carlo-Based Hyperspectral Scene Simulation*. Second Annual WHISPERS Conference. Reykjavik, Iceland. June 14-16. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5594835&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5594835

Subtopic b

1. H.N. Yum, et al. (2010). *Superluminal Ring Laser for Hypersensitive Sensing*. Optics Express. Volume 18. Issue 17. pp. 17658-17665. Available at http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-18-17-17658

2. D. D. Smith, et al. (2009). *Enhanced Sensitivity of a Passive Optical Cavity by an Intracavity Dispersive Medium*. Physical Review. Volume A. Issue 80. Available at http://journals.aps.org/pra/abstract/10.1103/PhysRevA.80.011809

3. C. Chen, et al. (1999). *Broadband Michelson Fiber-optic Accelerometer*. Applied Optics. Volume 38. Issue 4. p. 628. Available at http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-38-4-628

4. M.S. Shahriar, et al. (2011). *An Ultra-sensitive DC and AC Accelerometer Using Dual Superluminal Zero-Area L-shaped Ring Lasers*. Conference on Lasers and Electro-Optics, Baltimore, MD. Available at http://www.opticsinfobase.org/abstract.cfm?URI=CLEO:%20A%20and%20T-2011-ATuE1

Subtopic c

1. C. Borel & R. F. Tuttle. (2011). *Recent Advances in Temperature-emissivity Separation Algorithms*. IEEEAC paper. Volume 1743. Version 1 (978-1-4244-7351-9). Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5747397&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5747397

2. C.C Borel. (2003). *ARTEMISS – An Algorithm to Retrieve Temperature and Emissivity from Hyper-spectral Thermal Image Data*. 28th Annual GOMACTech Conference, Hyperspectral Imaging Session, March 31 to April 3, 2003. Tampa, Florida. Available at http://www.researchgate.net/publication/228967591_Artemiss-an_algorithm_to_retrieve_temperature_and_emissivity_from_hyper-spectral_thermal_image_data

3. A. Gillespie, et al. (1998). *A Temperature and Emissivity Separation Algorithm for Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Images*. IEEE Transactions on Geoscience and Remote Sensing. Volume 36 Issue 4. Available at http://www.researchgate.net/publication/3201882_A_temperature_and_emissivity_separation_algorithm_for_AdvancedSpaceborne_Thermal_Emission_and_Reflection_Radiometer_(ASTER)images

4. *MUSES (Multi-Service Electro-optic Signature).* ThermoAnalytics Corp. http://www.thermoanalytics.com/products/muses/index.html

Subtopic d

1. S.J. Arrowsmith. (2008). *Multi-Array Detection, Association and Location of Infrasound and Seismo-Acoustic Events in Utah*. 30th Monitoring Research Review - Ground-Based Nuclear Explosion Monitoring Technologies. Volume II. pp 844 - 852. Available at: https://www.researchgate.net/publication/235191883_Multi-Array_Detection_Association_and_Location_of_Infrasound_and_Seismo-Acoustic_Events_in_Utah

2. S.R. Taylor, S. J. Arrowsmith & D. N. Anderson. (2010). *Detection of Short Time Transients from Spectrograms Using Scan Statistics*. Bulletin of the Seismological Society of America. Volume 100. Issue 5A. pp. 1940–1951. Available at: https://www.researchgate.net/publication/228077101_Detection_of_Short_Time_Transients_from_Spectrograms_Using_Scan_Statistics

3. S.J. Arrowsmith, et al. (2010). *The Seismoacoustic Wavefield: A New Paradigm in Studying Geophysical Phenomena.* Review of Geophysics. Available at https://www.researchgate.net/publication/215754374_The_seismoacoustic_wavefield_A_new_paradigm_in_studying_geophysical_phenomena.

2. ALTERNATIVE RADIOLOGICAL SOURCE TECHNOLOGIES

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

This objective focuses on the R&D needed to replace high activity radioactive sources that are deemed to pose a significant risk if malevolently used. Our current emphasis is on emerging and innovative technologies and techniques for the replacement of these sources with non-radioisotope based technologies. Radioactive sources serve a number of critical functions including the treatment and diagnosis of disease, the inspection and certification of critical mechanical structures, the sterilization of food and medical products, and the exploration for petroleum. Replacements or alternatives proposed must provide equivalent (or improved) functionality and be less susceptible to malevolent use. Each proposal must address: economic feasibility of the proposed alternative or replacement, ease of maintenance (both the equipment and the source) and relative accessibility in and around the device.

DNN R&D holds an annual University Information Technical Interchange (UITI) program review meeting where University and SBIR projects are presented to the program managers. All awardees are required to attend and present their progress at this meeting each year.

Grant applications are sought only in the following subtopics:

a. Alternative Formation Density Well Logging Tool

Radioactive sources are commonly used in the well logging industry. The most accurate measurement of downhole rock porosity utilizes a tool that contains as much as 2.5Ci of ^{137}Cs. Replacement of these radioactive sources with an electronic alternative is sought. The replacement technologies must survive high temperatures (as high as 150 deg C), severe mechanical shocks and vibrations while in the well bore. In addition, small size and lightweight are absolutely necessary for ease of handling. In the proposals we will not consider an alternative physical form for the ^{137}Cs source.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

b. Replacement for Gamma-based Research Irradiators

Proposals are sought for electronic devices that can directly replace these large ^{137}Cs and ^{60}Co radiological sources. Research irradiators are highly specialized and a thorough understanding of the use requirements of the wide community will be needed to develop successful alternative technologies. Replacements should be precisely matched to the energy spectra and flux of current systems. Alternatively, a highly versatile and tunable source would be highly desirable.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

c. Replacements for the ^{241}Am/Be Neutron Sources for Well-logging

Proposals are sought for technologies to replace the ^{241}Am/Be sources used in traditional neutron well logging. Several neutron sources are commercially available, but none provide a direct replacement for ^{241}Am/Be. The Deuterium-Tritium and Deuterium-Deuterium energies (14 and 2.5 MeV, respectively) do not match the ^{241}Am energy spectrum (0-11 MeV with peaks at about 3 and 5 MeV. A tunable neutron source or one with an energy spectrum similar to ^{241}Am/Be is desired. The replacement technologies must have a reasonable operating lifetime in the presence of high temperatures (nominally ~150 deg C), severe mechanical shocks and vibrations while in the well bore. In addition, small size and light weight are absolutely necessary for ease of handling.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

d. Tags and Seals for Existing Radiological Sources

While the focus of this objective is to replace radiological sources in commercial use, an interim approach is to enhance the security of radiological materials in commercial use is to utilize established and emerging tagging technologies. Use of tagging technology could improve the security of highly portable sources used in nondestructive inspection and geophysical well logging applications. The requirement is to monitor the location of each source. Functional requirements would include long range (ideally by satellite or aerial survey), durability toward vibration and temperature, long lifetime, small size and low maintenance (battery-free would be best), and have the ability to sense radiation. It is also necessary to monitor whether the source is inside or outside shielding.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

References:

Subtopic a

1. National Research Council, Committee on Radiation Source Use and Replacement. (2008). *Radiation Source Use and Replacement: Abbreviated Version.* Washington, DC: The National Academies Press. ISBN: 978-0-309-11014-3. http://www.nap.edu/openbook.php?record_id=11976

2. W.A. Gilchrist, Jr., Feyzi Inanc & Loren Roberts. (2011). *Neutron Source Replacement - Promises and Pitfalls,* Presented at SPWLA 52nd Annual Logging Symposium, May 14-18, 2011. Available at https://www.onepetro.org/conference-paper/SPWLA-2011-KKK

3. A. Badruzzaman, et al. (2009). *Radioactive Sources in Petroleum Industry: Applications, Concerns and Alternatives.* Presented at SPE Asia Pacific Health, Safety, Security, and Environment Conference and Exhibition, August 4-5, 2009. SPE 123593. ISBN: 978-1-55563-260-1. Available at https://www.onepetro.org/conference-paper/SPE-123593-MS

Subtopic b

1. National Research Council, Committee on Radiation Source Use and Replacement. (2008). Radiation Source Use and Replacement: Abbreviated Version. Washington, DC: The National Academies Press. ISBN: 978-0-309-11014-3. Available at http://www.nap.edu/catalog.php?record_id=11976

Subtopic c

1. National Research Council, Committee on Radiation Source Use and Replacement. (2008). Radiation Source Use and Replacement: Abbreviated Version. Washington, DC: The National Academies Press. ISBN: 978-0-309-11014-3. Available at http://www.nap.edu/catalog.php?record_id=11976

2. The DOE/NRC Interagency Working Group on Radiological Dispersal Devices. (2003). *Radiological Dispersal Devices: An Initial Study to Identify Radioactive Materials of Greatest Concern and Approaches to Their Tracking, Tagging, and Disposition.* http://www.energy.gov/sites/prod/files/edg/media/RDDRPTF14MAYa.pdf

Subtopic d

1. National Research Council, Committee on Radiation Source Use and Replacement. (2008). Radiation Source Use and Replacement: Abbreviated Version. Washington, DC: The National Academies Press. ISBN: 978-0-309-11014-3. Available for purchase at http://www.nap.edu/catalog.php?record_id=11976

3. INTERNATIONAL SAFEGUARDS

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

This program supports NNSA's nuclear nonproliferation mission by developing innovative safeguards technologies to enhance verification of nuclear materials and activities. The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) includes R&D in nuclear (and relevant nonnuclear) measurements, field instrumentation and containment & surveillance. The program develops technologies to detect diversion of nuclear material from declared facilities, to detect undeclared nuclear material and activities from declared facilities, and to verify compliance with arms control treaties and agreements related to the control of nuclear material, its production or processing.

DNN R&D holds an annual University Information Technical Interchange (UITI) program review meeting where University and SBIR projects are presented to the program managers. All awardees are required to attend and present their progress at this meeting each year.

Grant applications are sought only in the following subtopics:

a. Develop, Testing, Assessing and Demonstrating Tamper Indicating Devices and Seals for Improving the Completeness of Chain of Custody and Continuity of Knowledge for Monitoring Containers

DNN R&D has a need for a handheld scanner for inspecting and authenticating welds on containers. The scanner should have spatial resolution of 20 microns, be able to scan a distance of one square foot in seconds at a distance of 1-6 inches from the surface. The scanner should have a battery life of 8 hours, operate at temperatures from -25 to 140 deg F and be radiation-hardened. Ideally, the user could directly compare images in the field.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

b. Compact Single Mode, Frequency Stabilized Laser Spectroscopy Sources

Frequency-stabilized, wavelength-tunable laser sources are needed to enable laser-based uranium isotope analysis. Highly-integrated, compact, frequency-stabilized laser sources having emission wavelengths (vacuum) at 639.7203 nm and 682.8838 nm are needed to replace conventional external cavity laser designs. Important performance metrics include, narrow spectral linewidth, minimal sensitivity to optical feedback and long lifetime with reliable wavelength tuning and setpoint repeatability. Desired integration features include thermal control, collimation, miniaturized optical isolation components, single-mode fiber coupling, and small package size.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Arden Dougan, Arden.Dougan@nnsa.doe.gov

References:

Subtopic a

1. G. Weeks, et al. *The Importance of Establishing and Maintaining Continuity of Knowledge During 21st Century Nuclear Fuel Cycle Activities.* Proceedings of the 53rd Annual Institute of Nuclear Materials Management Meeting. Orlando, FL 2012. Available at http://www.proceedings.com/18051.html

2. C.A. Pickett, et al. *Results from the 2010 INMM International Containment and Surveillance Workshop*. http://www.iaea.org/safeguards/symposium/2010/Documents/PapersRepository/099.pdf

3. C. A. Pickett, et al. *The Importance of Establishing and Maintaining Continuity of Knowledge during 21st Century Nuclear Fuel Cycle Activities.* Proceedings of the 53rd Annual Institute of Nuclear Materials Management Meeting. Orlando, FL, 2012. Available at https://inis.iaea.org/search/searchsinglerecord.aspx?recordsFor=SingleRecord&RN=43118558

Subtopic b

1. B.A. Bushaw & N.C. Anheier, Jr. (2009). *Isotope Ratio Analysis on Micron-Sized Particles in Complex Matrices by Laser Ablation – Absorption Ratio Spectrometry*. Spectrochimica Acta Part B: Atomic Spectroscopy. Volume 64. Issues 11-12. pp. 1259-1265. Available at http://www.sciencedirect.com/science/article/pii/S0584854709003231

2. N.C. Anheier, et al. (2012). *Safeguards Verification Measurements using Laser Ablation, Absorbance Ratio Spectrometry in Gaseous Centrifuge Enrichment Plants*. Journal of Nuclear Materials Management. Volume 40. Issue 4. pp 69-78. Available at http://www.osti.gov/scitech/biblio/1072909

3. N.C. Anheier, et al. (2014). *A Laser-based Method for Onsite Analysis of UF6 at Enrichment Plants.* Symposium on International Safeguards*:* Linking Strategy, Implementation and People - IAEA CN-

220. Vienna, Austria. 2014. Available at http://www-pub.iaea.org/iaeameetings/46090/Symposium-on-International-Safeguards-Linking-Strategy-Implementation-and-People

4. RADIATION DETECTION

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) is focused on enabling the development of next generation technical capabilities for radiation detection of nuclear proliferation activities. As such, the office is interested in the development of radiation detection techniques and sensors and advanced detection materials that address the detection and isotope identification of unshielded and shielded special nuclear materials, and other radioactive materials in all environments. In responding to these challenging requirements, recent research and development has resulted in the emergence of radiation detection materials that have good energy resolution. From these materials, the developments of radiation detectors that are rugged, reliable, low power and capable of high-confidence radioisotope identification are sought. Currently, the program is focused on the development of improved capabilities for both scintillator and semiconductor-based radiation detectors.

DNN R&D holds an annual University Information Technical Interchange (UITI) program review meeting where University and SBIR projects are presented to the program managers. All awardees are required to attend and present their progress at this meeting each year.

Grant applications are sought only in the following subtopics:

a. Handheld Detectors Using New Scintillator Materials

Spectroscopic handheld detectors incorporating a new scintillator, possibly coupled with a photomultiplier tube replacement technology. Low-cost, readily manufactured devices with performance equivalent, to or exceeding, Ce:$LaBr_3$ are of greatest interest.

Questions – contact: David Beach, David.Beach@nnsa.doe.gov

b. Photomultiplier Tube Replacement Technology

Alternatives requested to replace the existing PMT technology with new silicon photomultipliers (SiPM) used in a vast number of nuclear detectors. Important features needed are compatibility with high resolution detectors, signal shaping, voltage supply, temperature stabilization, high photodetection efficiency, dynamic range, and low thermal noise.

Questions – contact: David Beach, David.Beach@nnsa.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: David Beach, David.Beach@nnsa.doe.gov

References:

Subtopic a

1. G.F. Knoll. *Radiation Detection and Measurement*. J. Wiley Publishers. New York. Available at http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP001606.html

2. L.A Boatner, et al. (2013). *Bridgman Growth of Large SrI_2:Eu^{2+} Single Crystals: A High-performance Scintillator for Radiation Detection Applications*. Journal Of Crystal Growth. Volume 379. pp 63-68. Available at http://www.sciencedirect.com/science/article/pii/S0022024813000821

3. Zewu Yan, et al. (2014). *Eu^{2+}-activated $BaCl_2$, $BaBr_2$ and BaI_2 Scintillators Revisited*. NUCLEAR Instruments & Methods in Physics Research Section A-Accelerators, Spectrometers, Detectors, and Associated Equipment. Volume 735. pp 83-87. Available at http://www.sciencedirect.com/science/article/pii/S0168900213012552

Subtopic b

1. G.F. Knoll. (2010). *Radiation Detection and Measurement*. J. Wiley Publishers. New York. Available at http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP001606.html

2. G. Collazuol. (2012). *The SIPM Physics and Technology – a Review*. PhotoDet 2012. https://indico.cern.ch/event/164917/contribution/72/material/slides/0.pdf

5. NEUTRON AND GAMMA SOURCES FOR INTERROGATION

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) is focused on enabling the development of next generation technical capabilities for radiation detection of nuclear proliferation activities. As such, the office is interested in the development of interrogating D-D and D-T neutron sources that address the detection, imaging and isotope identification of unshielded and shielded special nuclear materials.

DNN R&D holds an annual University Information Technical Interchange (UITI) program review meeting where University and SBIR projects are presented to the program managers. All awardees are required to attend and present their progress at this meeting each year.

Grant applications are sought only in the following subtopics:

a. High Flux D-D Neutron Source

Develop and demonstrate significant advances in intensity, neutron energy-range, duty-cycle, or deployability of D-D neutron sources for the purpose of stimulating detectable radiation response in SNM and light materials of interest. The ideal system will produce at least 10^8 flux with a variable repetition rate and pulse width, weigh less than 20 lbs and fit in a backpack including the power supply.

Questions – contact: David Beach, David.Beach@nnsa.doe.gov

b. API D-T Neutron Source

Develop and demonstrate a 10^8 or greater flux D-T associated particle neutron (API) source that is deployable for the purpose of neutron transmission imaging. The ideal system will include a generator that is run continuous for over 1200 hours with a beam spot size of less than 5 mm, preferably 1 mm. The API detector will have a timing resolution of 1 ns or less and be man-portable.

Questions – contact: David Beach, David.Beach@nnsa.doe.gov

c. Instrumentation for Rapid Nuclear Material Assay with a Pulsed Associated Particle Neutron Generator

Active neutron interrogation of samples containing fissile species can offer rapid non-intrusive multi-element analysis. Fast neutrons penetrate shielding and induce prompt and delayed gamma-ray signatures. Concurrent recording of characteristic gamma ray signatures provides real-time material assays. In addition, neutron time-of-flight interrogation of the material of interest provides adequate signal/noise (S/N) ratios for elemental analysis. However, present capabilities of commercial neutron generators that allow neutron time-of-flight interrogation emit neutrons continuously and only signatures due to fast neutron reactions can be recorded while the neutron generator is in the ON state. Therefore, it is not possible to concurrently measure multiple signatures due to slow neutron interactions for which the neutron generator will need to be switched OFF. New developments in pulsed associated particle neutron generators offer the opportunity to probe fissile material in a new light. In particular, it will be possible to measure pre-fission inelastic gamma-ray signatures during the beam "ON" state of the generator and gamma-rays from fission products during the beam "OFF" state for a rapid assay of such material.

To be able to harness the full potential of the pulsed associated particle neutron generator, a multiple time gated data acquisition system would need to be developed for synchronously recording the temporal nature of the neutron induced gamma-ray emissions in real time.

The development of this instrument has the potential for wide commercial applications requiring materials characterization with high S/N. Separately, the developed digital data acquisition system is expected to advance the current state of multi-channel analyzers for fast radiation detectors and other applications requiring coincident radiation detection.

These instrument control and Digital Data Acquisition (DAQ) advances require development of firmware and software to be able to construct and display neutron time-of-flight spectrum and time gated neutron induced gamma-ray energy spectrum in real-time. The data acquisition will be expected to run synchronously with the pulsing of a neutron generator of the associated particle type and process signals from multiple detectors. An external gate signal will be imported from the neutron generator for recognizing the ON and OFF states of the generator. During the ON state, coincident events from the built-in alpha particle detector of the neutron generator and external gamma-ray detectors will be captured and time and corresponding energy spectrum will be histogrammed. Within each OFF state there will be user defined sub-periods during which gamma-ray events will be tagged and recorded for pulse height computation and histogramming. Counting statistics like input and output count rates and dead times for each set of spectra will be made available. The system should allow use of fast detectors like plastic scintillators, ZnO(Ga) in addition to HPGe, $LaBr_3$ and NaI(Tl) detectors. In addition, user controls for high voltage setting of detectors are required. The developed system will have a user friendly interface for all necessary manipulations of data acquisition and analysis.

Active interrogation with a pulsed associated particle neutron generator will revolutionize the field of prompt gamma neutron activation analysis (PGNAA) of materials. PGNAA has found wide applications as a rapid on-line multi-elemental analysis tool –to name a few in the coal, cement industries and security companies dealing with explosives detection. Instrument control and DAQ will be a vital component of all such systems and therefore has a vast commercial potential. The firmware and software that will be developed will be an intellectual property of the Small Business.

Questions – contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

d. Betatron or Equivalent Gamma Source

Develop and demonstrate a portable betatron or equivalent gamma source that provides 1 – 6 MeV gamma rays with a variable duty cycle. The goal is for the system to be less than 100 lbs and run on battery power.

Questions – contact: David Beach, David.Beach@nnsa.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: David Beach, David.Beach@nnsa.doe.gov

References:

Subtopic a

1. International Atomic Energy Agency. (2012). *Neutron Generators for Analytical Purposes*, IAEA Radiation Technology Reports No. 1. Vienna, Austria: IAEA. ISBN: 978-92-0-125110-7. Available at http://www-pub.iaea.org/books/IAEABooks/8505/Neutron-Generators-for-Analytical-Purposes

2. D. L. Chichester & J.D. Simpson. (2004). *Compact Accelerator Neutron Generators*. The Industrial Physicist. December 2003/January 2004. pp. 22-2. Available at http://qsl.net/k/k0ff//01%20Manuals/Neutron%20Reflection/Compact%20accelerator%20neutron%20generators%20-%20The%20Industrial%20Physicist.htm

Subtopic b

1. International Atomic Energy Agency. (2012). *Neutron Generators for Analytical Purposes*. IAEA Radiation Technology Reports. Number 1. Vienna, Austria. IAEA. ISBN: 978-92-0-125110-7. Available at http://www-pub.iaea.org/books/IAEABooks/8505/Neutron-Generators-for-Analytical-Purposes

2. D. L. Chichester & J.D. Simpson. *Compact Accelerator Neutron Generators*. The Industrial Physicist. December 2003/January 2004. pp. 22-2. Available at http://qsl.net/k/k0ff//01%20Manuals/Neutron%20Reflection/Compact%20accelerator%20neutron%20generators%20-%20The%20Industrial%20Physicist.htm

Subtopic c

1. H. Tan, et al. (2008). *A Multiple Time-gated System for Pulsed Digital Gamma-ray Spectroscopy.* Journal of Radioanalytical and Nuclear Chemistry. Volume 276. Issue 3. pp 639. Available at http://link.springer.com/article/10.1007%2Fs10967-008-0611-0

2. H. Tan, et al. (2007). *A Digital Spectrometer Approach to Obtaining Multiple Time-resolved Gamma-ray Spectra for Pulsed Spectroscopy*. Nuclear Instruments and Methods in Physics Research Section B. Volume 263. pp. 63. Available at http://www.sciencedirect.com/science/article/pii/S0168583X07008270

3. Y. Zhou, et al. (2012). *Modelling the Tagged-neutron UXO Identification Technique Using the Geant4 Toolkit.* Journal of Radioanalytical and Nuclear Chemistry. Volume 294. Issue 1. pp 37.Available at http://link.springer.com/article/10.1007%2Fs10967-011-1466-3

Subtopic d

1. *Betatrons*. http://web.mit.edu/course/22/22.09/ClassHandouts/Charged%20Particle%20Accel/CHAP11.PDF

2. V.L. Chakhlov, et el.(1999). *Photoneutron source based on a compact 10 MeV betatron.* Nuclear Instruments and Methods in Physics Research Section A. Volume 44. Issues 1-3. pp 5-9. Available at http://www.sciencedirect.com/science/article/pii/S0168900298011061

3. M. Stein, et al. *Small-Size Betatrons for Radiographic Inspection*. World Conference on Nondestructive Testing. Montreal, Quebec (Canada). Aug. 30 – Sept. 3, 2004. http://www.ndt.net/article/wcndt2004/pdf/radiography/104_stein.pdf

6. TECHNICAL NUCLEAR FORENSICS – POWDER SUB-SAMPLING

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

Representative sub-sampling of powders is important in making accurate and precise measurements in technical nuclear forensics (TNF) and other applications. Powder samples may be comprised of particles with non-uniform size and density distributions. These distributions must be maintained in the individual sub-samples to ensure that measurement results are technically rigorous and defensible. The small quantity and radioactivity of many TNF samples add additional challenges to the sample splitting process – for example, it is often required to manipulate the powder sample in a glovebox environment. Commercially available powder subsampling technologies have limitations when applied in these contexts.

Grant applications are sought only in the following subtopics:

a. Representative Subsampling Technical Methods

There are several widely recognized procedures for sub-sampling or splitting powder samples [Ref. 1]. Manual processes such as cone & quartering or scooping are compatible with the nuclear material and radiological safety environment in which TNF samples are processed. However, these techniques are not considered ideal when the sample is not homogenous. The best practice in the case of non-homogeneous powders where the particle size and density vary is to sample when the 'bulk' powder is in motion. Commercial-off-the-shelf (COTS) instruments such as rotary rifflers are available that can produce high quality, representative sub-samples but they are designed to process a larger amount of material than is generally preferred for TNF work and may not be compatible with the nuclear safety environment in which the samples are processed. Further specifications for a TNF powder subsampling technology are identified below.

Sample Characteristics

- The amount of sample to be split is generally 1gram or less. This may represent all the available material or the amount that is safe to handle in a given environment.
- The samples can be susceptible to hold-up due to static or stickiness. Due to the limited sample size, the sub-sampling process needs to be efficient and retain as little of the sample as possible.
- Prevention of background-to-sample and sample-to-sample cross contamination is paramount.

- TNF powder samples can vary widely. The powders can have mutli-modal particle size distributions, particles with different densities, and other features that must be accurately reproduced in the sub-samples.

Operating Environment:

- Any technology employed as part of the sub-sampling process should be compatible with radiological gloveboxes as they are deployed and operated at U.S. Department of Energy laboratories. Relevant technical issues include those identified below.
- Standard glovebox ports range from 10 to 15 inches in diameter. Any equipment or instrumentation should be able to pass through such a port or should be able to be disassembled for transport into the glovebox.
- Several layers of gloves are often worn in addition to the glovebox gloves, which hampers dexterity. Mechanical manipulations should be simplified to aid the operator. Equipment should have no sharp edges, objects, or pinch points that could potentially damage the containment gloves.
- Operation should minimize the amount of waste generated and not introduce any RCRA or CERCLA listed species [Refs 3,4].
- Use of flammables and combustibles should be minimized.

Questions – contact: Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

b. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

References:

Subtopics a-b

1. A. Jillavenkatesa, S.J. Dapkunas & L.H. Lum. (2001). *Particle Size Characterization*. National Institute of Standards and Technology. Special Publication 960-1. http://www.ceramics.nist.gov/ftproot/PracticeGuides/960-1/SP960-1.pdf

2. K.J. Moody, I.D. Hutcheon & P.M. Grant. (2005). *Nuclear Forensic Analysis*. Boca Raton, FL. CRC Press. Available at https://www.scribd.com/doc/120032321/Nuclear-Forensic-Analysis

3. *Resource Conservation and Recovery Act (RCRA)*. http://www.epa.gov/agriculture/lrca.html

4. *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).* http://www.epa.gov/agriculture/lcla.html

5. *American Glovebox Society.* http://www.gloveboxsociety.org/prod_serv.html

7. HIGH PERFORMANCE FIBER OPTIC LINK FOR REMOTE INSTRUMENTATION

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

A fiber-optic link would find many applications to reliably transmit information to and from instruments operating in harsh, dangerous, and/or noisy environments. One application is for equipment that must be placed in areas of high electronic background noise, or that must function to withstand an electromagnetic pulse and other environmental conditions. A fiber-optic link can connect such equipment to associated digitizers and other electronics that are in a separate location, for data transfer.

Grant applications are sought only in the following subtopics:

a. Fiber-optic Link for Remote Instrumentation

An analog high-bandwidth fiber-optic link with a 1-km range is of interest to develop in order to connect instruments that must operate in electronically noisy environments to expensive digitizers and control electronics that are located elsewhere.

A fiber-optic link has advantages over coaxial cable, including greater bandwidth, extended range, and reduced size and weight. However, most available analog fiber-optic links have limited signal fidelity. Pulse overshoot and ringing are common, and deviations from linearity can be significantly greater than 1%. In many precision instrumentation applications pulse overshoot and ringing must be eliminated, and deviations from linearity limited to less than 0.3%.

A second requirement is high bandwidth. The minimum bandwidth must be 1 KHz to 1 GHz. Higher bandwidths are also of interest; 10 KHz to 10 GHz, and 100 KHz to 100 GHz would find significant instrumentation applications. The frequency response must be flat to +/- 3 dB to preclude signal distortion.

Pulse overshoot must be less than 5% of the pulse amplitude, and ringing must be reduced to 1% of pulse amplitude within twice the pulse rise time.

The range of the analog instrument fiber-optic link must be at least 1 km.

Electrical input and output must be compatible with 50 Ohm impedance coaxial cable. The 50 Ohm electrical input full scale amplitude must be 5 Volts, and the 50 Ohm electrical output must have a full scale amplitude of 1 Volt. The dynamic range must be at least 1,000:1.

The link may be based on direct modulation or Mach-Zehnder modulation with deconvolution in post processing, or may be based on other technologies.

Questions – contact: Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

b. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

References:

General

1. Y. Chiu, et al. (1999). *Broad-band Electronic Linearizer for Externally Modulated Analog Fiber-optic Links.* Photonic Technology Letters. Volume 11. Issue 1. pp 48. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=736386&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D736386

2. K. Williams, et al. (1998). *Photodetector Nonlinearity Limitations on a High Dynamic Range 3 GHz Fiber Optic Link.* Journal of Lightwave Technology. Volume 16. Issue 2. pp 192. Available at http://www.opticsinfobase.org/jlt/abstract.cfm?uri=jlt-16-2-192

3. V. Urick, et al. (2009). *Analysis of an Analog Fiber-optic Link Employing a Low-biased Mach-Zehnder Modulator Followed by an Erbium-doped Fiber Amplifier*. Journal of Lightwave Technology. Volume 27. Issue 12. Available at http://www.opticsinfobase.org/jlt/abstract.cfm?uri=jlt-27-12-2013

8. HIGH-TRANSMISSION, NARROW-BAND TUNABLE FILTERS OPERATING IN THE ULTRAVIOLET FOR APPLICATIONS IN MULTI- AND HYPER-SPECTRAL IMAGING

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

Tunable optical filters have recently been commercialized for visible wavelengths. These filters have enabled the creation of hyperspectral imaging systems for the creation of image data cubes, where images can be obtained for narrow wavelength bins, providing large amounts of information about the observed scene (point-by-point optical spectra). However, hyperspectral imaging systems operating in the ultraviolet (UV) are not yet available, and significant effort will needed to extend existing tunable filter technologies into the ultraviolet regime with high transmission efficiency. Emphasis should be placed on creating a robust technology that can be used in a field setting. The most important criteria are narrow transmission band (sub-nm), high transmission efficiency (>60%), 1” or greater aperture, rapid tunability, little image degradation, wide angular acceptance (> 5° half angle) and high out-of-band rejection (less than 0.01% out of band transmission). Example technological approaches include Fabry-Perot interferometers, acousto-optic tunable filters, and liquid crystal tunable filters. The UV range of interest is the near-UV, of wavelengths of about 400nm down to approximately 300nm. In some applications, the durability of the filter while subjected to an optical spectrum and intensity that is solar-like (on the earth's surface) is also an important feature.

The development of a UV tunable filter has the potential for wide commercial relevance in fields such as machine vision, atmospheric metrology, biomedical microscopy, explosives detection, and spectroscopic materials characterization systems.

Grant applications are sought only in the following subtopics:

a. Acousto-optic, Fabry-perot, or Liquid Crystal UV Tunable Filter

To create a fieldable UV tunable filter, all of the criteria described above should be met simultaneously. The challenges for extending each of these technologies into the UV will be different. For example, the primary limiting factor for acousto-optical filters may be the diffraction efficiency (transmission) for UV operation, while Fabry-Perot interferometers may be limited by their sensitivity to dust in a field setting. Liquid crystal tunable filter materials may be challenged by their durability in being subjected to a solar-like optical spectrum and intensity.

Multiple filter or filter types can be used together to reject out-of-band light, so long as a clear concept for a single tunable filter system operating in the UV is presented. The system should be computer-controllable with high repeatability in the selection of a specific wavelength of interest. If all of the criteria described above cannot be met, a proposed filter design should identify how it can perform as a UV hyperspectral imaging system and which criteria are the greatest challenge to meet.

Questions – contact: Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

b. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

References:

Subtopics a-b

1. M.E. Martin, et al. *An AOTF-based Dual-modality Hyperspectral Imaging System (DMHSI) Capable of Simultaneous Fluorescence and Reflectance Imaging*. Medical Engineering & Physics. Volume 28. pp 149-155 (2006). Available at http://dx.doi.org/10.1016/j.medengphy.2005.04.022

2. J. Mäkynen, et al. (2012). *Multi- and Hyperspectral UAV Imaging System for Forest and Agriculture Applications*. Proceedings. SPIE. Volume 8374. Available at http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1354105

3. Kalasinsky, K.S. et al. "Raman Chemical Imaging Spectroscopy Reagentless Detection and Identification of Pathogens: Signature Development and Evaluation," Analytical Chemistry, Vol. 79, pp 2658-2673, (2007). Available at http://dx.doi.org/10.1021/ac0700575

9. TECHNOLOGY TO FACILIATE MONITORING FOR NUCLEAR EXPLOSIONS

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

Ground-based Nuclear Detonation Detection Research and Development (GNDD R&D) is sponsored by the U.S. Department of Energy's National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research and Development (DNN R&D). GNDD is responsible for the research and development necessary to provide the U.S. Government with capabilities for monitoring nuclear explosions. The goal of the GNDD Team is to advance the U.S. ground-based nuclear explosion monitoring capabilities to detect, locate, identify and determine yield of events associated with foreign nuclear weapons development (see Reference 1). Proposals that enhance U.S. capabilities that also benefit the international monitoring capabilities in the context of preparations for a Comprehensive Nuclear-Test-Ban Treaty (CTBT) may be submitted.

Research is sought to move toward commercialization of algorithms, hardware, and software that advance the state-of-the-art for event detection, location, and identification. Superior technologies will help improve the Air Force Technical Applications Center's (Reference 2) ability to monitor for nuclear explosions, which are banned by several treaties and moratoria. Grant applications responding to this topic must state: (1) the current state-of-the-art, in terms of relevant specifications such as sensitivity, reliability, maintainability, etc., as well as the performance goal of the proposed advance in terms of those same specifications; and (2) address the commercialization path of any instruments or components developed. Due to the small market potential of treaty monitoring technologies, this call is focused toward already existing or emerging commercial products for other applications that could be modified/enhanced for treaty monitoring applications. The resulting "treaty monitoring edition" of the product(s) would hopefully provide a performance advantage that would also benefit the original market and thereby leverage existing markets.

Existing infrasound sensors typically comprise a single pressure transducer attached to a wind-noise reduction system. Such sensors are typically configured in arrays, with three or more elements, to obtain direction-of-arrival (DOA) information and for further noise reduction through cancellation of incoherent pressure fluctuations. A good review of existing infrasound noise reduction strategies is provided by Walker and Hedlin (2010). There are a number of limitations of such existing sensors, including the following:

- Existing wind noise reduction strategies introduce distortions in the sensor pressure data response that must be corrected.

- Several existing strategies for noise reduction depend upon spatial averaging of the sampled pressure field in order to reduce the effects of small-scale pressure variations; a method that results in a large footprint per individual sensor.

- Increasing traditional spatial filter length past an optimal length leads to no improvement in signal-to-noise ratio, but instead starts to attenuate the frequencies of interest.

- Several existing strategies for noise reduction (e.g., porous hoses) are suitable for temporary but not long-term deployments as the hose properties change due to weathering.

- Arrays of sensors are needed to obtain DOA information, which is costly and requires a large footprint.

- Calibration of the sensor response in the field is difficult, because the sensor response consists of both the wind reduction system and instrument response.

Grant applications are sought only in the following subtopics:

a. Infrasound Sensor Improvement and Commercialization

Improvements to infrasound sensors are needed that:

- Can be commercialized through leverage by having utility beyond nuclear explosion monitoring.

- Lead to quantifiable improvements in wind noise reduction systems in terms of enhancements to the signal-to-noise level across the full range of frequencies of interest (0.02 – 100 Hz).

- Can provide for improved calibration methods when compared to current equipment. Both the amplitude and phase response of the distributed sensor (or sensor + noise reduction system) can be determined in situ.

- Can provide improved power use efficiencies and/or reduced footprint over existing commercial sensors

The table below highlights a minimum set of requirements for any analog sensor that would be developed under this SBIR call. These specifications are based in part on the CTBTO sensor requirements.

Property	Threshold
Frequency Response	0.02 – 100 Hz

Dynamic Range	>108dB
Resolution	Accurately resolve real variations of 1 mPa at 1 Hz
Sample Rate	Capable of being sampled at 2 kHz
Self Noise	≤ 18 dB (relative to 20 micro-Pa)
Absolute Stability	Remain within limits of < 5% in absolute amplitude for the duration of 1 year.
Mean Time Between Failure	At least 1 year in an operating environment of -40 C to 70 C and humidity @ 95%
Cost	Shall be competitive with existing technology
Testing	Shall be independently tested at a national calibration laboratory to ensure developer specifications are correct.
Power	Shall not exceed power requirements of existing sensors and ideally minimize power needs

Questions – contact: Leslie Casey, Leslie.Casey@nnsa.doe.gov

b. Other

In addition to the specific subtopic listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Leslie Casey, Leslie.Casey@nnsa.doe.gov

References:
Subtopics a-b

1. A. Casey. (2014). *Ground-based Nuclear Detonation Detection (GNDD) Team – Goals, Objectives and Requirements*. Document Number DOE/NNSA/NA-22/GNDD-GOR-2014) DOI: 10.2172/1130078. Available at http://www.osti.gov/scitech/biblio/1130078

2. *United States National Data Center*. Air Force Technical Applications Center. http://www.usandc.gov

3. K.T. Walker & M. Hedlin. (2010). *A Review of Wind-Noise Reduction Methodologies*. Infrasound Monitoring for Atmospheric Studies. DOI: 10.1007/978-1-4020-9508-5. Available at http://link.springer.com/chapter/10.1007/978-1-4020-9508-5_5

PROGRAM AREA OVERVIEW: OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

The U.S. electric power sector is a critical part of our society. The electricity industry is a mix of investor-owned utilities, municipal utilities, cooperatives, and federal power utilities. In addition, electricity is also generated from non-utility power producers. The nation's electric grid must be protected from unacceptable risks, multi-regional blackouts, and natural disasters. Therefore, the mission of the Office of Electricity Delivery and Energy Reliability (OE) is to lead national efforts in applied research and development to modernize the electric grid for enhanced security and reliability. A modernized grid will significantly improve the Nation's electricity reliability, efficiency, and affordability, and contribute to economic and national security.

OE supports research and development efforts to eliminate bottlenecks, foster competitive electricity markets, and expand technology choices. For example, the risk of multi-regional blackouts and natural disasters can be reduced through the application of better visualization and controls of the electric grid, energy storage and power electronics, smart grid technology, cyber security, and advanced modeling.

10. INNOVATIVE SIC AND GAN-BASED TOPOLOGIES FOR GRID-TIED ENERGY STORAGE APPLICATIONS

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: NO
Accepting STTR Phase I Applications: NO	Accepting STTR Fast-Track Applications: NO

Grid-tied energy storage systems are becoming more prevalent in the electric utility infrastructure and critical in the advancement of the electric grid. Energy storage systems provide multiple economic and technical benefits, such as increasing the value of renewables such as wind and photovoltaic systems, providing flexibility for the customer, maintaining power quality, and increasing asset utilization and deferring upgrades of the grid. Integrated systems utilizing energy storage will ultimately improve the reliability, quality, security, flexibility, and ultimately the cost effectiveness of the existing and future electric utility infrastructure. The trend in energy storage systems is to package the energy system including energy storage technology and power electronics in a standard shipping container for the ease of transport and siting. Industry is attractive to this because they have lower installation cost compared to traditional approach and less installation time to operation. The containerized approach provides unique challenges for the power conversion system, as well as the energy storage technology. With this added form factor, high power density design and increased performance is required to increase efficiency and reliability, reduce thermal management, and ultimately reduction in overall cost. In addition, as the high density design is needed special consideration is needed to make sure these systems have a safe and reliable operation. There has been an increase interest in the utilization of advanced semiconductor devices known as Wide Band Gap (WBG) devices such as SiC and GaN in a number of switch mode power conversion system including applications in stationary energy storage systems. It has been shown that these devices when used in advanced power conversion topologies can result in increased efficiencies and higher power density compared to silicon-based systems and, thus, is attractive to containerized energy storage systems. Packaged SiC and GaN devices such as diodes and insulated gate bipolar devices (IGBTs) are starting to reach the power electronics marketplace and their full system benefits are yet to be demonstrated in single and three phase energy storage systems. Advances in WBG-based power conversion topologies for grid-tied energy storage systems are sought. Advanced power conversion topologies for battery, flywheel, electrochemical capacitor, and superconducting magnetic energy storage will only be considered.

Grant applications are sought in the following subtopics:

a. High Voltage and High Density SiC-based Topologies for Grid-tied Energy Storage Applications

Energy storage systems used today typically require a dc-dc pre-conversion followed by a dc-ac inverter that is tied to the grid via a 60 hz transformer. Each energy storage technology such as batteries and flywheels has unique requirements in regards to maximum power transfer from the energy storage device to the grid and vise-versa. Flywheel energy storage systems for example, has variable frequency and AC electromechanical power output that needs to be conditioned before an inversion process takes place via the inverter. Some advanced topologies have been talked about for flywheel energy storage system such as matrix converters that convert directly from AC to AC without a need for DC link. Batteries on the other hand, require a dc to dc pre-conversion prior to the inverter. Two terminal SiC devices such as Schottky diodes have been in the marketplace for a few years now. The three terminal devices such as MOSFETS and IGBTs are starting to enter the marketplace. These devices have the potential to switch at higher frequencies, higher breakdown voltages, and higher junction temperatures compared to silicon. Applications are sought for advanced topologies utilizing SiC devices to significantly improve grid-tied energy storage systems. The desired properties include: (a) transformerless three-phase >12.47 kVac output, (b) >100 kW power rating, (c) convection cooled thermal management system, (d) bidirectional capability, and (e) >2X power density improvement over traditional design. Proposals must show significant system improvements over silicon-based designs and maximum system benefits of utilizing SiC devices. The advanced topologies must cover the entire conversion process from the energy storage device to the electric utility connection.

Questions – contact: Imre Gyuk, imre.gyuk@hq.doe.gov

b. High Voltage and High Density GaN-based Topologies for Grid-tied Energy Storage Applications

GaN devices have emerged more recently with promising characteristics such as high frequency and high density power conversion designs. By providing low gate charges due to high electron mobility and low on-resistance, GaN-based semiconductor devices can allow for high switching frequencies and reduced switching losses resulting in high power density power conversion system design. Applications are sought for advanced topologies using GaN-based semiconductor switches to improve grid-tied energy storage systems. Desired properties include: (a) transformerless three-phase >480 Vac output, (b) >75 kW power rating, (c) convection cooled thermal management system, (d) bidirectional capability, and (e) >2X power density improvement over traditional designs. Proposals must show significant system improvements over silicon-based designs and maximum system benefits of utilizing

GaN devices. The advanced topologies must cover the entire conversion process from the energy storage device to the electric utility connection.

Questions – contact: Imre Gyuk, imre.gyuk@hq.doe.gov

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Subtopic b

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PROGRAM AREA OVERVIEW: OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

The Office of Energy Efficiency and Renewable Energy (EERE) is at the center of creating the clean energy economy today. EERE leads the U.S. Department of Energy's efforts to develop and deliver market-driven solutions for energy-saving homes, buildings, and manufacturing; sustainable transportation; and renewable electricity generation.

The EERE mission is to strengthen America's energy security, environmental quality, and economic vitality in public-private partnerships to enhance energy efficiency and productivity; bring clean, reliable and affordable energy technologies to the marketplace; and make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life. EERE's role is to invest in high-risk, high-value research and development that is critical to the nation's energy future and would not be sufficiently conducted by the private sector acting on its own. EERE Technology Office efforts directly support the President's Climate Action Plan goals of doubling renewable electricity generation by 2020 and doubling energy productivity by 2030. On September 17, 2014, U.S. Secretary of Energy Moniz announced a partnership with the Council on Competitiveness and the Alliance to Save Energy to launch Accelerate Energy Productivity 2030 to grow our economy while reducing our energy costs.

EERE's Technology Offices all have multiyear plans, detailed implementation processes and have demonstrated impressive results. To access this information for a particular office, click here. Program activities are conducted in partnership with the private sector (including small businesses), state and local governments, DOE national laboratories, and universities. EERE also works with stakeholders to develop programs and policies to facilitate the deployment of advanced clean energy technologies and practices. EERE's fiscal year 2015 budget request can be found here: http://energy.gov/sites/prod/files/2014/04/f14/Volume%203.pdf.

For additional information regarding EERE's priorities, click here.

11. ADVANCED MANUFACTURING

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

The Advanced Manufacturing Office (AMO) (www1.eere.energy.gov/manufacturing/) partners with industry, small business, universities, and other stakeholders to identify and invest in emerging technologies with the potential to create high-quality domestic manufacturing jobs and enhance the global competitiveness of the United States. Wide bandgap (WBG)-based power electronics and light-emitting diodes (LEDs) promise to be more efficient, powerful, and less costly than conventional electronics. The use of domestic natural gas for feedstock and fuel substitution enables more energy-efficient manufacturing than today's state-of-the-art. Innovative systems for the production of carbon fiber and for synthesizing novel atomically precise catalysts represent critical platform materials for a wide variety of clean energy applications. New technologies now can cost-effectively recover previously inaccessible low grade industrial waste heat and use it to reduce industrial fuel use.

All applications to this topic must:

- Be consistent with and have performance metrics (whenever possible) linked to published, authoritative analyses in your technology space.
- Clearly define the proposed application, the merit of the proposed innovation compared to competing approaches, and the anticipated outcome with a special emphasis on the commercialization potential of the overall effort including Phase I and Phase II.
- Applications should provide a path to scale up in potential Phase II follow on work.
- Include quantitative projections for price and/or performance improvement that are tied to representative values included in authoritative publications or in comparison to existing products. For example, projections of price or cost advantage due to manufacturing improvements, materials use, or design simplification should provide references to current practices and pricing to enable informed comparison to present technologies.
- Demonstrate commercial viability with a quantifiable return on DOE investment as described elsewhere in this FOA.
- Fully justify all performance claims with thoughtful theoretical predictions and experimental data.

Grant applications are sought in the following subtopics:

a. Wide Bandgap Semiconductors for Energy Efficiency and Renewable Energy

Wide bandgap (WBG) semiconductor-based devices — with bandgaps significantly greater than 1.7 eV — operate at much higher voltages, frequencies, and temperature than conventional semiconductor-based devices.[1-3] DOE has made significant R&D investments in WBG semiconductors. [4] WBGs--including silicon carbide (SiC), gallium nitride (GaN), zinc oxide (ZnO), aluminum nitride (AlN) and diamond (C) offer dramatic improvements in a variety of applications such as power electronics, solid-state lighting, fuel cells, photovoltaics, and sensing in harsh environments.

Compared to today's Si-based technologies, devices using WBGs can operate at higher temperatures, operate at greater voltages over time, and switch at much higher frequencies than those based on non-WBG substrates. Depending on current density, power dissipation, and reverse breakdown voltage requirements, semiconductor devices are structured as either vertical or lateral structures. While vertical SiC and lateral GaN/(SiC, Si, Sapphire)-based semiconductor devices are commercial, vertical GaN devices (LEDs and power devices) built on GaN substrates and vertical AlN or AlGaN devices (UV-C LEDs and power devices) built on AlN substrates are not. Making commercial vertical LEDs on GaN and AlN or AlGaN substrates would have major power and efficiency advantages including: greater brightness (2-3x); higher current tolerance; and smaller and less expensive chips due to improved geometry compared with LEDs on other substrates such as Sapphire. To develop these applications, the substrates must be conducting, and LED substrates also must be transparent. These properties are controlled by point defects in the substrates, so identifying and eliminating these point defects is a key research goal.

Research areas below are important for the fabrication of conducting and transparent(e.g. LED) substrates; for improved doping control during boule and epi-growths; and for increasing scientific understanding of relatively deep donor and acceptor levels, ion-implantation, and subsequent activation of donor and acceptor impurities. [5]

Areas of particular interests include:

<u>Substrate Forming from Bulk GaN Crystals</u>: While much R&D has been conducted on the methods for growing low defect, low-optical-absorption bulk GaN crystals, significant advances are still required to make epi-ready substrates. GaN has similar mechanical properties to SiC [6], and many mechanical forming methods such as slicing, grinding, and mechanical polishing can be adapted from SiC. As each step in the epi-ready substrate formation process is highly dependent on the preceding step, it is important to adapt these operations in a concurrent, balanced manner.

Mechanical shaping steps must be cost effective and minimize subsurface damage; achieve reasonable wafer shape (as measured by bow, warp, and total thickness variation and local thickness variation); and consider requirements for scaling diameter and volume. After mechanical polishing, final surface preparation with chemo-mechanical polishing (CMP) steps are required to remove surface and subsurface damage and present a high quality surface to grow low-defect epitaxial films. Developing a commercially viable CMP process with a reasonable removal rate requires a thorough study of chemistries and mechanical (down) forces with careful control of all interacting parameters such as chemistry, temperature, down-force, linear abrasion speed, viscosity, slurry flow rates and concentrations. The difficulty with CMP on relatively hard crystals such as GaN and SiC is in achieving a viable removal rate while balancing all process parameters to create a smooth surface. Removal rates can also be heavily influenced by crystallographic orientation, defect density, defect size, defect type, and doping / impurity type and concentration. The final steps required include non-destructive surface characterization techniques that can be performed with high speed and accuracy at low cost. Of particular interest is the ability to measure sub-surface damage, which is currently impossible using optical microscopy.

<u>Doping Control and Producing Shallow Donors in AlN Substrates and Epilayers</u>: Improving control of dopant incorporation and production of shallow donors is critical during boule and epi growth. Applications are sought that show a path to the controlled incorporation of shallow donors (<100 meV) in AlN substrates and/or thick (>10 µm) epilayers grown on AlN or other suitable WBG substrates. AlN substrates with thick epilayers and n-type (vertical) conduction are needed for a wider array of devices including both LEDs and power devices. While AlN-based LEDs producing light at between 200-300 nm are already being commercialized for water purification, it is still difficult to obtain n-type conduction for AlN substrates and epilayers [7, 8, 9, and 10]. An understanding of the doping mechanism and of controlled and reproducible doping in AlN is needed to manufacture these vertical structures. A Si concentration of $3x10^{19}$ cm-^{3} is the upper doping limit for achieving n-type conductive Si-doped AlN. At that limit, the highest electron concentration of $9.5x10^{16}$ cm-^{3} has been obtained [11].

Questions – contact: anant.agarwal@ee.doe.gov

b. Natural Gas Feedstock and Fuel Substitution for Energy Efficient Manufacturing

The recent emergence of new supplies of natural gas in the United States, along with the use of more energy efficient technologies, has the potential to increase competitiveness in American manufacturing [1, 2]. Point-of-use, on-demand production systems in miniaturized chemical processing systems could offer improved environmental and safety benefits [3]. The realization of these benefits depends on the availability of low cost, modular process technologies that overcome low economy of scale issues and mitigate demonstration risks [4]. Plasma reforming of natural gas offers the opportunity for process intensification [5]. Applications are sought to develop novel thermal and non-equilibrium (also called cold plasma) reactors for manufacturing valuable products from natural gas. Selective conversion is sought to produce useful products such as acetylene, carbon black, or high performance carbon materials. As this subtopic focuses on reactor development, proposals should clearly demonstrate existing pathways to integration of any necessary catalysts. Novel processes must show improvements to yield, selectivity, and economics compared to state-of-the art technology.

Questions – contact: Stephen Sikirica, stephen.sikirica@ee.doe.gov

c. Carbon Fiber Production Processes

Due to their high strength-to-weight ratio, stiffness, and outstanding corrosion resistance properties, carbon fiber composites can be used to lightweight: vehicles, next generation blades for wind and other turbine technologies, and high pressure storage tanks for natural gas and hydrogen. Several challenges remain for carbon fiber composites to achieve widespread adoption. Current carbon fiber technology relies primarily on polyacrylonitrile (PAN) precursors, a polymer of acrylonitrile (ACN). ACN in turn is made from petroleum (propylene) and natural gas (ammonia) feedstocks. The precursor PAN-based material is subject to convection heating in an oxidation oven and subsequent high-temperature carbonization. These processes are energy-intensive and generate high levels of off-gases that must be treated before being released. To reduce these problems, EERE has supported potentially lower-energy methods of converting precursor material to the final fiber form such as the development of atmospheric plasma technologies and microwave assisted plasma-based technologies. [1]

Areas of particular interest include

Low Energy Conversion of Polyacrylonitrile to Carbon Fiber:

EERE is seeking innovative and novel processes that are less energy- and carbon- intensive compared to the standard oxidation and carbonization steps used to convert PAN-based precursors to carbon fiber. The deliverable for this area should demonstrate a minimum of 25% reduction in energy intensity over fiber production in current commercial practice. The deliverable must show, through the synthesis of carbon fiber, with sufficient experimental measurements and supporting calculations, that cost-competitive energy savings can be achieved with practical economies of scale. Applications should provide a path to scale up in potential Phase II follow on work. Applications involving the use of atmospheric plasma or microwave assisted plasma technologies are outside the scope of this topic area.

Novel Catalytic Routes to Direct Synthesis of Carbon Fiber from Gas or Solution Phase

Advances in the design and synthesis of solid atomically-precise enzyme-like catalytic structures offer the potential for direct conversion of low-cost chemicals to solid products [2-5]. AMO seeks to advance solid catalyst technology for the production of carbon fiber from low cost chemicals in a commercially competitive and scalable processing approach. The subtopic deliverable should demonstrate a minimum of 25% reduction in energy intensity over fiber production in current commercial practice. The deliverable must show, through the physics-based design and synthesis of atomically precise solid catalysts, (with sufficient experimental measurements and supporting calculations), that the technology could feasibly synthesize carbon fiber. It also must show that cost-competitive energy savings can be achieved with practical economies of scale. Applications should provide a path to demonstration of carbon fiber synthesis (if not actual synthesis), and to process scale up in potential Phase II follow on work.

Questions – contact: Kelly Visconti, kelly.visconti@ee.doe.gov

d. Novel Low Cost Recovery from Low Temperature Industrial Waste Heat

The industrial sector accounts for about 31 Quads [1] of energy consumption, more than any other sector in the American economy. An estimated 20-50% [2] of this energy consumption is lost as waste heat. While some of this waste heat is at high temperatures, and is easily recovered using conventional recovery technologies, a substantial portion - as much as 60% [3] - is at temperatures below 450ºF, often in highly diffuse form. While thermo-electric (TE) technologies can be used to convert this heat directly into electricity, their low efficiencies (<10%) and high costs (>3$/watt) make them unattractive options. Advances in nanotechnology and nanofabrication have enabled new direct conversion (heat to electricity) technologies that have the potential to surpass the performance of TE systems. Some illustrative examples include plasmonics [4], thermionic emission [5], and vibration energy harvesting [6].

Applications are sought for novel low-cost approaches to direct energy conversion for low temperature (<450ºF) industrial waste heat streams that could significantly improve the energy efficiency of the industrial sector. Responses outside of the examples above are welcome, as they are for illustrative purposes only. Performance targets include a conversion efficiency between 20% to 30% (Electricity output measured as a fraction of thermal energy input) with a manufacturing cost <$1/W. The proposed technology must have adequate robustness for utilization in challenging industrial operations. Applications must show a credible path from early stage development through potential Phase II follow on work, to ultimate commercialization.

Questions – contact: Bob Gemmer, bob.gemmer@ee.doe.gov

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Subtopic b

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Subtopic c

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4. *Materials Synthesis.* Institute for Atom Efficient Chemical Transformations. Argonne National Laboratory, http://web.anl.gov/catalysis-science/materials_synthesis.html

5. Center for Molecular Electrocatalysis. Pacific Northwest National Laboratory. http://efrc.pnnl.gov/

Subtopic d

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3. BCS, Inc., 2008, page 54, http://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/waste_heat_recovery.pdf

4. Plasmonics, ISSN: 1557-1955, 1557-1963, http://link.springer.com/journal/11468

5. Thermionic Energy Conversion, https://quantum.soe.ucsc.edu/research/tec.html

6. Center for Energy Harvesting Materials and Systems (CEHMS), http://www.me.vt.edu/cehms/

12. BIOENERGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Biomass is a clean, renewable energy source that can significantly diversify transportation fuels in the United States. The U.S. Department of Energy's Bioenergy Technologies Office (BETO) (http://energy.gov/eere/bioenergy) is helping to transform the nation's renewable and abundant biomass resources into cost-competitive, high-performance biofuels, bioproducts, and biopower. BETO is focused on forming partnerships with key stakeholders to develop, demonstrate, and deploy technologies for advanced biofuels production from lignocellulosic and algal biomass.

All applications to this topic must:

- Be consistent with and have performance metrics (whenever possible) linked to BETO's recently updated Multi-Year Program Plan (MYPP) that is available for download directly at: http://energy.gov/eere/bioenergy/downloads/bioenergy-technologies-office-multi-year-program-plan-july-2014-update
- Clearly define the proposed application, the merit of the proposed innovation, and the anticipated outcome with a special emphasis on the commercialization potential of the overall effort including Phase I and Phase II;
- Applications should provide a path to scale up in potential Phase II follow on work.
- Include quantitative projections for price and/or performance improvement that are tied to representative values included in the MYPP or in comparison to existing products. For

example, projections of price or cost advantage due to manufacturing improvements, materials use, or design simplification should provide references to current practices and pricing to enable informed comparison to present technologies.

- Demonstrate commercial viability with a quantifiable return on DOE investment as described elsewhere in this FOA.
- Fully justify all performance claims with thoughtful theoretical predictions or experimental data.

a. Design and Fabrication of Solids Handling for Biomass Conversion Systems

Lack of continuous solids handling is one of the main barriers to continuous operation of biomass conversion systems. Robust handlers are needed to continuously move biomass feedstock from ambient conditions into a controlled reactor environment. Grant applications are sought for designs, prototype equipment, and procedures that enable continuous biomass solids handling at 10% lower cost than currently available. The continuous handling into a controlled reactor environment must meet the in-feed specifications of the conversion technology Examples of in-feed specifications are located in two design reports (PNNL-23053/NREL/TP-5100-61178; NREL/TP-6A2-46588) that are available electronically at http://www.osti.gov/bridge. Consideration will be given to ideas that allow for multiple feedstocks, easy manufacturability (including use of non-specialized construction materials), or other features that would enable feedstock from ambient conditions to be continuously moved into the reactor environment used by multiple conversion technology providers.

Questions – contact: Mark Elless, mark.elless@ee.doe.gov

b. Low-Cost Coatings for Advanced Thermal Processes in Metal Combustors

As the use of biomass increases for power, products and fuels, one challenge is the reliability of the combustors in the harsh conditions in the reacting zone (high-temperature typically >600°C, with some local hot spots up to ~800 to 900°C). One of the most challenging components at the higher temperatures is the combustor made from lower-cost metal alloys. In addition to surviving the high-temperatures, the combustor must endure a corrosion/materials challenge due to the presence of both aggressive chemicals such as halide salts (e.g. NaCl, KCl, etc.) and water vapor released from the biomass fuel (e.g. grass, wood, charcoal, agricultural residue). When the need for low-cost alloys to permit widespread adoption of sustainable feedstocks is also considered, these conditions pose a major durability/cost challenge.

Grant applications are sought for the development of low-cost protective coatings for metal combustors. Coating approaches potentially of interest may include, but are not limited to: ceramic coatings, alloy coatings, aluminizing treatments, surface modifications/reactive surface treatments, thermal spray, wash coats, vapor deposition or sputtering (if sufficiently low cost), plating, and porcelains/enamels.

For this application's intended end-user market, the metal combustor component design must be produced for $5-10 (assume generic 0.5–1.0mm thick substrate alloy as a cylinder with a 15cm diameter and 30cm height), offer hot use lifetimes of several years (minimum of ~1000 hours per year) and comply with all federal, state and local emissions regulations. The candidate coatings should resist high-temperature corrosion, be compatible with lower-cost ferritic and/or austenitic substrate alloys (e.g. steels, 9Cr steels, lower alloyed 200 or 300 series stainless steels, FeCrAls), and be able to coat the (typically) curved inner surfaces of the combustor. Applicants must include a coating cost estimate task in the Phase I work plan This plan must include both coating raw material and processing for a simplified cylindrical wall inner surface (15 X 30 cm) that is projected for high volume production. The Phase I work plan should also include high-temperature corrosion screening assessments of the candidate coatings (small test sample form is acceptable) relative to the uncoated substrate alloy and/or a benchmark uncoated alloy such as a 300 series stainless steel or FeCrAl. The test conditions must be relevant to biomass, i.e. ≥ 600°C. Either lab furnace simulations or direct exposure are acceptable for Phase I work. The use of a salt or other relevant corrosive species in the high-temperature corrosion testing is encouraged but not required.

Questions – contact: Neil Rossmeissl, neil.rossmeissl@ee.doe.gov.

c. Solid-Liquid Separations for Algal Systems

The recent growth in bioenergy R&D focus on algal systems is due in part to their high growth rate and high oil content. However, cost reduction is required for algal energy to become widespread. The cost of solid-liquid separation, including algae concentration and dewatering, is a critical driver for initial capital, energy and resource costs of algal fuel and products. Algae grown in open ponds and photobioreactors are dilute (0.1–0.5 grams per liter) and currently require multiple concentration steps. Multiple separation technologies might substitute for these multiple process steps, but only if these technologies are integrated in an optimal (unit operation) fashion. The purpose of this subtopic is to support such integration. Specifically it seeks commercial processing technologies that as a unit operation produces slurry with 20–30% solids from a dilute 0.5 grams/liter algal feed. The applicant should consider as a minimum the following technology options [1] for integration:

- Vacuum Filters
- Pressure Filters
- Hydroclones
- Screens and or sieving, and
- Gravity tables

Other technologies, such as flocculation, may be considered, provided the evaluations in the application consider the cost of the chemicals. For the required comparison of energy and cost parameters, the applicant must use – as a baseline – the integration of dissolved air floatation with centrifuges to achieve the desired solids concentration. Applications must show a final 25–30% reduction in capital cost [2], a 20% reduction in energy demand, and a solids concentration of at least 20%.

Questions – contact: Neil Rossmeissl, neil.rossmeissl@ee.doe.gov

References:
Subtopic c
1. K. Erickson and J. Hedrick. (1999). *Plant-Wide Process Control*. Chapter 11. pp. 305-355. ISBN: 0-471-17835-7. 1999 Chapter 11 (pp. 305-335). http://www.pacontrol.com/process-information-book/Solid%20Liquid%20Seperation%2093851_11.pdf

2. *Process Automation Control*. Online Training/Tutorial. http://www.pacontrol.com/

13. BUILDINGS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

DOE's Building Technologies Office (BTO) advances building energy performance through the development and promotion of efficient, affordable, and high impact technologies, systems, and practices. BTO's long-term goal is to reduce buildings' energy use by 50%, compared to a 2010 baseline. To secure these savings, research, development, demonstration, and deployment of next-generation building technologies in both the commercial and residential buildings sector are needed to advance building systems and components that are cost-competitive in the market. Energy efficient lighting has enormous potential to conserve energy and enhance the quality of our commercial, industrial and residential building inventory. Electric lighting now consumes ~1/10th of the primary energy delivered annually in the U.S., representing ~22% of the electricity produced. Energy storage and distributed generation technologies are used increasingly for base or peak load generation. BTO is dedicated to promoting the widespread and effective use of these technologies to meet its long term goal.

Grant applications are sought in the following subtopics:

a. Energy Efficient Solid-State Lighting Luminaires, Products, and Systems

The DOE has estimated that advancing energy efficient electric lighting in U.S. buildings could conserve more than 50% of lighting energy with corresponding savings in electricity costs to building operators. These technologies also could reduce costs with reductions in power generation load – especially during peak consumption. Although the DOE and the general illumination industry in North America have already realized substantial energy conservation in this end use, even more energy conservation is possible using advanced luminaire designs, constituent products and systems that take full advantage of the unique performance capabilities of Solid-State Lighting (SSL). This subtopic aims specifically at identifying and stimulating the commercial introduction of advanced and energy efficient SSL luminaires, SSL components and SSL systems in the three broadly defined categories below.
All applications to this subtopic must:

- Be consistent with and have performance metrics (whenever possible) linked to either the recently updated 2014 DOE SSL Multi-Year Program Plan (MYPP) [1] that is available for download directly at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf or the DOE SSL Manufacturing Roadmap [2] available for download at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mfg_roadmap_aug2014.pdf
- Clearly define the proposed application, the merit of the proposed innovation, and the anticipated outcome with a special emphasis on the commercialization potential of the overall effort including Phase I and Phase II;
- Include quantitative projections for price and/or performance improvement that are tied to representative values included in the MYPP or in comparison to existing products [3]. For example, projections of price or cost advantage due to manufacturing improvements, materials use, or design simplification should provide references to current practices and pricing to enable informed comparison to present technologies.
- Demonstrate commercial viability with a quantifiable return on DOE investment as described elsewhere in this FOA.
- Fully justify all performance claims with thoughtful theoretical predictions or experimental data.

SSL Luminaires and Lamps -- Today, SSL luminaires are widely available in an array of direct traditional source replacements and in common lamp replacements such as A-line lamps, PAR lamps, and small linear fluorescent lamps or compact fluorescent lamps. Luminaire designs are available with integrated SSL sources in flat panel architectures that directly replace wall sconces, decorative and safety lighting products and in suspended ceiling luminaires. New, novel and highly energy efficient designs are sought in any of these product areas that build on the unique performance attributes of the SSL source to achieve significant improvements in overall luminaires or lamp performance. Applications are sought for designs that are revolutionary, imaginative, impactful, and that could have a significant impact on introducing SSL in important general illumination markets. Designs that are already under development or that represent incremental or evolutionary improvements over current products are not of interest under this topic.

SSL Components, contributing materials, constituents or integral products – Many individual components and materials (for advanced optoelectronic device packaging/manufacturing) are used in the manufacture of SSL including highly-engineered intermediate products. These components include power supplies, current spreading devices, out coupling enhancement lenses, and specialty materials such as index matching silicones and epoxies [1]. Applications are sought for replacements or alternatives to these intermediate components, materials, or constituents that could significantly advance the performance of SSL products while simultaneously reducing cost or manufacturing complexity. Such intermediate dedicated products might be part of a thermal management solution, optical delivery and management architecture, power supply, or some other aspect of a modern, energy efficient SSL design. Successful applications should represent innovative, high performance and cost-competitive alternatives. Incremental or evolutionary advancements to existing materials, constituents, or intermediate products are not of interest.

SSL Systems – One of the most important performance attributes of SSL is their direct current (DC) operation, which makes them inherently compatible with digital controls, sensors (e.g. motion sensors, occupancy sensors, ambient light intensity and quality sensors) and DC renewable energy sources such as solar cells.

This attribute, however is not typically a featured element or capability of commercial SSL products. If this traditionally unused attribute were incorporated into SSL product design, their inherent power compatibility with other digital peripherals (due to avoided DC to AC to DC conversion) could lead significant energy conservation. Self-commissioning lighting control systems that easily accommodate variations in interior décor or seasonal adjustments in lighting quality are an example of how novel integration and digital controls may be able to conserve lighting energy much more easily with SSL than with most traditional light sources. It is also possible that advanced controls and digital features could accelerate the market penetration of various SSL luminaires or lamps by adding valued features not presently available with traditional sources. BTO therefore seeks novel system designs or integrated product concepts that represent both novelty and innovation in concept as well as demonstrable lighting energy conservation potential.

Questions – contact: James Brodrick, james.brodrick@ee.doe.gov

b. Integrated Storage and Distributed Generation for Buildings

DOE's BTO seeks to identify energy storage and distributed generation technologies not for emergency generation, but for base or peak load electricity generation in commercial and residential building stock. Applications must specify the intended market(s) for the technology and justify the improved performance relative to a representative building within that market. Preference will be given to technology solutions that are applicable to the existing building stock. Applicants are expected to provide quantitative analysis, with all assumptions clearly stated, that supports the performance and economic targets for the proposed technology.

Areas of interest include:

1) Integrated thermal and/or electrical energy storage systems for buildings that could reduce carbon emissions from the building sector by a minimum of 25% with the baseline defined by EIA [3].

Applications must meet the following requirements:

Performance: Reduction in operating carbon emissions (not embodied)
Minimum of 25% compared to an existing building (for retrofits) or a new building built to existing code. Greater carbon emissions reductions are anticipated for commercial buildings than residential buildings.

Economics: Simple payback including a full balance-of-system (with installation and any complementary distributed generation technology).The simple payback can take into account time-of-use and/or demand response utility rates, if applicable. Detailed justification that the calculated payback is acceptable for the intended market(s)

2) Building-Integrated Solar Electricity Generator (SEG) technologies to offset fossil-fuel primary energy consumption by 10% and 5%, respectively, for residential and commercial buildings. This subtopic is not focused on developing new solar electricity generators (SEG), but rather seeks to integrate SEGs with building materials.

Applications must meet the following requirements:

- Performance
- System integration (Inverter, storage, etc.)
- Reliability, aesthetics etc.
- Long-term durability relative to existing fire, structure, moisture, and acoustic codes; applications should illustrate that the proposed technology will not have detrimental impacts on the building structure or thermal performance
- Economics
- Cost of the integrated building material and SEG system
- Calculation of simple payback (the replacement building materials could be used as baseline); detailed justification that the calculated payback is acceptable for the intended market(s)
- Minimum added installation costs compared to replacement building materials

All applications for this subtopic should include modest feasibility studies in Phase I, and transition to manufacturing in Phase II. BTO strongly encourages applicants to include a strategy for obtaining partners in the building material industry by the end of Phase 1 as a part of their commercialization plan. Successful applications will offer products or components that provide value to customers at a greatly reduced cost (compared to the state-of-the art) or by being readily reconfigured to meet evolving market trends.

All applications to this subtopic must:

- Clearly define the proposed application of the technology, the merit of the proposed innovation, and the anticipated outcome of the overall effort including Phase I and Phase II
- Demonstrate commercial viability with a quantifiable return-on-DOE-investment as described elsewhere in this FOA.

Questions – contact: Karma Sawyer, karma.sawyer@ee.doe.gov

References:
Subtopic a

1. *Solid-state Lighting Research and Development.* (2014). United States Department of Energy Energy Efficiency and Renewable Energy. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf

2. *Solid-state Lighting Research and Development Manufacturing Roadmap*. United States Department of Energy Energy Efficiency and Renewable Energy. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mfg_roadmap_aug2014.pdf

3. *Annual Energy Outlook 2014. (2014).* United States Energy Information Administration. http://www.eia.gov/forecasts/aeo/

Subtopic b

1. Overall Sector Wide Emissions. http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2014&subject=13-AEO2014&table=17-AEO2014&region=1-0&cases=ref2014-d102413a

2. Overall Sector Wide Energy Consumption. http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2014&subject=13-AEO2014&table=2-AEO2014&region=1-0&cases=ref2014-d102413a

3. Alternatively, applicants may use one number per state using the following table; however, they are expected to show the technologies' performance at a national level http://www.eia.gov/environment/emissions/state/analysis/pdf/table7.pdf

14. FUEL CELLS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

The Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office (FCTO) (http://www1.eere.energy.gov/hydrogenandfuelcells) works in partnership with industry (including small businesses), academia, and DOE's national laboratories to establish fuel cell and hydrogen energy technologies as economically competitive contributors to U.S. transportation needs. A roadmap for the development of fuel cell and hydrogen technologies that guides FCTO investments aimed at lowering the related risks and costs can be found here: http://energy.gov/eere/fuelcells/fuel-cell-technologies-office-multi-year-research-development-and-demonstration-plan.

The FCTO aims to build on other early niche market successes in applications such as fuel cell-powered lift trucks by helping industry initiate another market in motive power applications and enable a robust domestic supply base. The FCTO Market Transformation subprogram helps drive down costs, develops a supply base, and provides a strategic pathway to high volume manufacturing as part of establishing an industry in transportation applications. This subprogram is a key component that moves technologies from the laboratory to self-sustaining commercialization in the marketplace. The subprogram's market-acceleration strategy evaluates and aids deployment of commercially ready fuel cell technology applications. The primary goal of the Market Transformation subprogram is to increase penetration of hydrogen and fuel cell technologies in key early markets by developing business cases for emerging commercial applications.

Grant applications are sought in the following subtopics:

a. Fuel Cell-Battery Electric Hybrid for Utility or Municipal MD or HD Bucket Trucks

Medium duty (MD) and heavy duty (HD) vehicles (Classes 3-8) consume 22% of the petroleum used annually by the United States vehicle fleet. This oil usage is driven primarily by the size of the vehicle fleet—about 11.9 million vehicles—and the age of the vehicle fleet, with about 4.2 million pre-2000 vehicles in operation. Low fuel economies and a slow turnover rate, with new vehicle sales averaging about 600,000 units annually, have resulted in continued high oil usage in class 3-8 vehicles. While diesel engines now dominate new vehicle sales of class 3-8 vehicles [1], the diesel share is declining. This decline is partly due to an increase in other types of vehicles including those based on gasoline engines; flex fuel engines, and alternative fuel engines, such as compressed natural gas engines and plug-in hybrid electric (PHEV) engines.

Vehicle electrification is underway for MD and HD bucket trucks, which are used by line crews employed by electric utilities, natural gas utilities, telecommunications companies, and municipalities. These trucks typically spend a significant amount of time (and diesel fuel) idling at the work site to power the truck's hydraulic boom, lights, auxiliary equipment, and cabin heating and cooling. Work crews also use emergency generators to supplement the power provided by the bucket trucks' internal combustion engines. Electric Power Take-off (ePTO) systems have been commercially introduced as a clean technology alternative to combustion engine idling to provide remote power to work crews [2]. The ePTO systems use batteries that are integrated into the bucket trucks, both with and without drivetrain integration. These batteries are either charged by the grid or while driving between work sites.

The FCTO seeks applications with projects that develop and demonstrate polymer electrolyte membrane (PEM) fuel cell-battery electric hybrid trucks for MD or HD bucket trucks with drivetrain-integrated ePTO systems. Low temperature PEM fuel cells operate on hydrogen fuel at relatively low temperature and are well-suited to both motive and stationary operation. PEMFCs are considered a key electric energy-conversion technology for this application. EPTO systems have an onboard inverter and a transfer switch breaker to enable the vehicle to serve as a portable backup power unit to support critical loads during power outages, thus eliminating the need for engine idling or use of remote generators including during emergencies, such as extended power outages. Utility and municipal fleets are a critical first market on the path to mainstream electrification. This subtopic aims to accelerate the development and production of cost-effective on-board, fuel cell-battery electric drivetrains that substantially increase the electric driving range and remote exportable power capabilities of bucket trucks used by utilities and municipalities.

Applications are sought for technology and business solutions that will help: establish a business case, mitigate the cost of hydrogen fuel infrastructure, supplement utility industry evaluations of introducing hydrogen generation on their grids, and demonstrate fuel cell-battery electric hybrid truck technologies.

Expected Outcomes

Phase I

- A design feasibility analysis and plan describing the power system and truck designs and specifics (e.g. cost, performance requirements). Plans should use well established references, including a model analysis report [3] by Argonne National Laboratory: "The Benefits of Using a Fuel Cell Auxiliary Power Unit to Double the Range of Current Battery Electric Vehicles," as guides for planning hydrogen fuel consumption, cost trade-offs, and other impacts of using a small fuel cell to extend the driving range of a battery electric vehicle.
- An economic assessment, including a payback analysis, concerning the use of hydrogen-fueled PEM fuel cells for fuel cell hybrid trucks used as MD or HD bucket trucks with drivetrain-integrated ePTO systems. Assessments should include intrinsic value proposition factors such as any operations or productivity gains (e.g. avoided residential community noise, energy and petroleum fuel savings, scheduled maintenance advantages, emissions reductions, availability of remote power during extended outages or remote service calls, and other benefits).

Phase II

- One (1) fuel cell power system unit (approximately10 to 30 kW) delivered and installed on commercially available MD or HD bucket truck with drivetrain-integrated ePTO system and tested for a minimum of 200 hours of real world operations.
- Final report describing operations testing performance results and a commercialization plan.

Questions – contact: Peter Devlin, peter.devlin@ee.doe.gov

Applicants to Technology Transfer Opportunity (TTO) subtopic below should review the section describing Technology Transfer Opportunities on page 9 of this document prior to submitting applications.

b. TECHNOLOGY TRANSFER OPPORTUNITY: In-line Quality Control Devices Applicable to PEM Fuel Cell MEA Materials

The FCTO has supported Manufacturing R&D to address industry-identified technical barriers to the scale-up of PEMFCs for mobile, stationary, and portable applications. One barrier to scale-up is the lack of in-line quality control techniques developed and validated for the continuous (roll-to-roll) production of membrane-electrode-assembly (MEA) components. FCTO supports the development and validation of in-line quality control techniques for MEA components production. The FCTO has funded the National Renewable Energy Laboratory (NREL) to develop non-destructive techniques with the resolution, sensitivity, and measurement rate to tackle this barrier. NREL has developed a suite of techniques applicable across all of the MEA components and has begun validating these techniques with state-of-the-art MEA materials. For example, NREL has used a direct current excitation/infrared detection diagnostic to map out material defects in moving gas diffusion media and catalyst-coated membrane sheets on a manufacturing webline. The thermal response from the fuel cell material (or absence of signal from a defect) is captured by an infrared camera. In addition, NREL has used an optical reflectance diagnostic to map material thickness and defects in moving membrane sheets on a manufacturing web-line. The reflectance signal from the fuel cell material (or absence of signal from a defect) is captured by an array detector. To encourage industry's uptake of these technologies, DOE seeks small businesses to design and develop commercially viable Quality Control (QC) devices for ultimate implementation by fuel cell and fuel cell component manufacturers. DOE expects that these devices could be applicable to a wide variety of industries and material sets beyond PEM fuel cell MEA components.

Applications are sought that meet the critical need for in-line quality control devices for PEM fuel cell MEA component manufacturing processes. Awardees must design and fabricate a QC device that is readily implementable in a roll-to-roll production line for the production of one or more MEA component materials. It is expected that the successful applicant will, using their own expertise in developing similar techniques, work to improve the resolution, sensitivity, measurement speed, or other critical parameters of the device. Awardees must develop a marketing plan for the device that would include but not be limited to the PEMFC industry, based on existing, emerging, and expected markets.

The work that is envisioned must involve Technical Transfer of NREL IP on optical techniques for monitoring continuous manufacturing of proton exchange membrane fuel cell components (U.S. Patent Application US13/405,129).

Licensing Information:

National Renewable Energy Laboratory
Contact: Anne Miller (anne.miller@nrel.gov; 303-384-7353); Ty Ferretti (ty.ferretti@nrel.gov; 303-275-4353)
Patent Status: U.S. PatentApplication: US13/405,129
USPTO Link: http://appft1.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PG01&p=1&u=/netahtml/PTO/srchnum.html&r=1&f=G&l=50&s1=20130226330.PGNR.

Questions – contact: Nancy Garland, nancy.garland@ee.doe.gov

References:

Subtopic a

1. Reference for diesel with a 77.5% share at the end of March 2014.

2. Edison Electric Institute. (2014). *Transportation Electrification: Utility Fleets Leading the Charge*. June 2014. www.eei.org/issuesandpolicy/electrictransportation/FleetVehicles/Documents/EEI_UtilityFleetsLeadingTheCharge.pdf

3. P. Sharer & A. Rousseau. (2013). *Fuel Cells as Range Extenders for Battery Electric Vehicles.* Department of Energy Hydrogen Program and Vehicle Technologies Annual Merit Review. Project ID Number MT012. May 15, 2013. Available at http://www.hydrogen.energy.gov/pdfs/review13/mt012_rousseau_2013_o.pdf

Subtopic b

1. National Renewable Energy Laboratory. (2014). *Fuel Cell MEA Manufacturing R&D.* June 18, 2014. Presentation available at http://www.hydrogen.energy.gov/pdfs/review14/mn001_ulsh_2014_o.pdf
2. M. Ulsh, et al. (2014). (2007). *Fuel Cell Membrane Electrode Assembly Manufacturing R&D.* July 16, 2007. http://www.hydrogen.energy.gov/pdfs/progress13/vi_1_ulsh_2013.pdf

15. GEOTHERMAL

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

The heat energy from the earth represents an enormous and underutilized domestic resource. The Office of Energy Efficiency and Renewable Energy's Geothermal Technologies Office (GTO) (www1.eere.energy.gov/geothermal/) works in partnership with industry (including small businesses), academia, and DOE's national laboratories to establish geothermal energy as an economically competitive contributor to the U.S. energy supply. Information on GTO priorities and future directions can be found in the fiscal year 2015 Budget overview at http://energy.gov/sites/prod/files/2014/03/f9/fy15_at-a-glance_gto.pdf.

In 2013, GTO outlined the underlying technology needs that will guide research and ultimately determine commercial success for geothermal energy production. Two strategic roadmaps trace the Energy Department's investments, past and present, and tie them to these needs to guide future GTO research. The report for geothermal exploration technologies can be found here: http://www.eere.energy.gov/geothermal/pdfs/exploration_technical_roadmap2013.pdf, and the report for Enhanced Geothermal Systems (EGS) can be found here: http://www.eere.energy.gov/geothermal/pdfs/stanford_egs_technical_roadmap2013.pdf.

GTO also conducts research, development, and demonstration projects throughout the United States on low-temperature and coproduced geothermal and geopressured resources. Recent funding opportunities have enabled GTO to support work that extends into sedimentary basins, including geothermal resources collocated within oil and natural gas fields. GTO strives to demonstrate innovative technologies that will lead to advanced geothermal and geopressured energy use and electricity production in these currently underutilized resource areas.

All applications to this topic must include:

- Specific performance metrics that, whenever possible, are consistent with and linked directly to the GTO roadmaps and priorities as described above,
- a description of the merit of the proposed innovation,
- anticipated outcomes of Phase I and Phase II,
- a path to phase up to potential Phase II follow on work, and a
- full justification for all performance claims based on thoughtful theoretical predictions or experimental data.

Grant applications are sought in the following subtopics:

a. Innovative Products or Technologies that Develop New Markets/Revenue Streams for Geothermal Energy

GTO seeks to fund the development and commercialization of innovative products or technologies that will expand current markets utilizing geothermal energy for electricity production or direct use applications. A major hindrance to the wider development and use of geothermal energy is high capital costs, modest market size, and limited technology penetration, which contribute to a lag in creating needed economies of scale. In the context of this subtopic, we define geothermal energy as any useful application of naturally occurring heat from beneath the earth's surface; however, GTO specifically excludes from this subtopic products or technologies that are solely improvements to geothermal ground source heat pumps. Expanding market accessibility to geothermal energy and technologies directly supports the President's Climate Action Plan goals of doubling renewable electricity generation by 2020 and doubling energy productivity by 2030.

As part of a response to this subtopic, applicants must clearly define their target market, describe why geothermal energy has either not been developed or has been under-utilized within that market, and describe how their proposed product or technology will increase wider penetration of geothermal energy. These markets can be geographic (i.e. eastern United States), new technological applications (i.e. power storage or other ancillary services), new revenue streams (i.e. cascading direct use), or others. GTO welcomes all innovations, whether they are high definition subsurface imaging or a waste heat bottoming cycle, so long as the applications include a detailed explanation of how the proposed product or technology could expand market availability to the geothermal energy sector. The applicant also must show how the proposed innovation will lead to a reduction in the risks and/or cost of geothermal energy technology development leading to new market commercialization.

Questions – contact: Josh Mengers, joshua.mengers@ee.doe.gov

Applicants to Technology Transfer Opportunity (TTO) subtopic below should review the section describing Technology Transfer Opportunities on page 9 of this document prior to submitting applications.

b. TECHNOLOGY TRANSFER OPPORTUNITY: Enabling Geothermal Co-produced Applications by Employing Electromagnetic Manipulation of Magnetizable Oil

Coproduced resources use heat and/or pressure in fluids produced from oil, gas, and other material harvesting processes to generate electricity as well as in direct use applications. While the quality of the resource depends on water volume and temperature, these technologies have the potential to add value streams to existing operations. Applications for low-temperature geothermal energy beyond power generation (including material extraction, industrial processes, space heating and cooling, aquaculture, agricultural drying, water purification, and radiant heating) continue to gain ground in the United States.

Improving current oil/gas/water separation technologies has the potential to enable wider use of coproduced geothermal resources. GTO seeks to fund the further development and commercialization of the electromagnetic manipulation of magnetizable oil (U.S. Patent No. 8795519-Fermi National Accelerator Laboratory) to create a product that separates hydrocarbons from other produced fluids to enable geothermal coproduced applications. For example, the technology can be used as part of a water purification system or a mineral recovery system. The application should make clear how the technology could reduce the costs of operation/waste disposal or add value by the recovery of a useful resource. In order to be selected, the proposed technology must incorporate the use of geothermal resources, which can be accomplished either by using the coproduced resource to power the operation of the technology or by clearly showing how the byproduct streams enable the coproduced resource to be further developed economically. The proposed technology also must be able to operate at commercial flow rates of a minimum of 10,000 barrels per day total volume, with the ability to accommodate larger volumetric flow rates preferred. The proposed technology should offer an improvement over current state of the art for the removal of dispersed oil, which consists of small droplets suspended in the aqueous phase that are typically 4-6 microns in size. Current treatment systems typically cannot remove droplets smaller than 10 microns. An ancillary goal of this project is to treat produced waters to the EPA limit of oil and grease (O&G) which is 42 mg/L daily maximum.
Fermi National Accelerator Laboratory Information:

Licensing Information:
Fermi National Accelerator Laboratory
Contact: Cherri Schmidt (cherri@fnal.gov; 630-840-5178)
TTO Tracking number: FAA-815
Patent Status: U.S. Patent 8,795,519 Issued 5 August 2014
USPTO Link: http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PTXT&s1=%22electromagnetic+boom%22&OS=

Questions – contact: Josh Mengers, joshua.mengers@ee.doe.gov

References:
Subtopic b

1. J. Veil, et al. (2004). *A White Paper Describing Produced Water from Production of Crude Oil, Natural Gas, and Coal Bed Methane*. Prepared by Argonne National Laboratory for the United States Department of Energy, National Energy Technology Laboratory. http://seca.doe.gov/technologies/oil-gas/publications/oil_pubs/prodwaterpaper.pdf

2. A. Fakhru'l-Razi, et al. (2009). *Review of Technologies for Oil and Gas Produced Water Treatment*. Journal of Hazardous Materials. Volume 170 Issues 2-3. pp. 530-551. Available at http://www.sciencedirect.com/science/article/pii/S030438940900778X

3. Balch, Robert, et al. (2012). *Cost-Effective Treatment of Produced Water Using Co-Produced Energy Sources for Small Producers*. RPSEA Small Producer Program Final Report. Available at http://www.rpsea.org/projects/07123-05/

16. SOLAR

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

The Office of Energy Efficiency and Renewable Energy's SunShot Initiative (SunShot) (http://energy.gov/eere/sunshot/sunshot-initiative) is working in partnership with industry, academia, national laboratories, and other stakeholders to achieve subsidy-free, cost-competitive solar power by 2020. The potential pathways, barriers, and implications of achieving the SunShot Initiative price reduction targets and resulting market penetration levels are examined in the SunShot Vision Study (http://www1.eere.energy.gov/solar/sunshot/vision_study.html).

In this topic, SunShot seeks applications for the development of innovative and impactful technologies in the areas of:

(a) Analytical and Numerical Modeling and Data Aggregation
(b) Concentrating Solar Power: Novel Solar Collectors
(c) Concentrating Solar Thermal Desalination
(d) Grid Performance and Reliability
(e) Labor Efficiencies through Hardware Innovation

Applications may be submitted to any one of the subtopics listed above but all applications must:

- Propose a tightly structured program which includes technical milestones that demonstrate clear progress, are aggressive but achievable, and are quantitative;

- Include projections for price and/or performance improvements that are tied to a baseline (i.e. SunShot targets and/or state of the art products or practices);
- Explicitly and thoroughly differentiate the proposed innovation with respect to existing commercially available products or solutions;
- Include a preliminary cost analysis;
- Justify all performance claims with theoretical predictions and/or relevant experimental data

Grant applications are sought in the following subtopics:

a. Analytical and Numerical Modeling and Data Aggregation

The capability to efficiently collect, store, manipulate, and visualize vast, diverse, and complex streams of data can transform the operations of stakeholders throughout the solar value chain: from electric utilities managing distributed generation on their infrastructure; to solar fleet operators designing maintenance schedules; to solar sales lead generations seeking to reduce customer acquisition soft costs.

Applications are sought for the development of innovative data and simulation tools. Tools should provide actionable insights; use existing datasets or collect non-redundant datasets; and advance state-of-the-art modeling and visualization techniques. Areas of interest include, but are not limited to: (1) predictive analytics applied to solar resource forecasting, accurate technology adoption prediction, or operation and maintenance modeling; (2) advanced performance verification and validation tools; (3) novel techniques of and methods for capturing, aggregating, and analyzing structured or unstructured datasets; (4) aggregation and anonymization of solar performance and reliability data from residential, commercial, and utility scale installations to assign actionable, credible statistics for financing and underwriting; (5) consumer-facing decision-making platforms leveraging social and new media; and (6) incorporation of nearly real-time energy consumption data (e.g., applying smart meter data). Areas not of interest include device-level modeling.

Questions – contact: solar.sbir@ee.doe.gov

b. Concentrating Solar Power: Novel Solar Collectors

Concentrating solar power (CSP) collectors capture the solar flux and direct the photons to a receiver, where they are converted to heat. The heat is then typically absorbed by a fluid and transferred to a thermal energy storage unit or to a power block, where it is used to generate electricity. Collectors can be categorized as (i) non-tracking, (ii) single-axis tracking and (iii) dual-axis tracking. The greater the tracking control, the smaller the cosine losses. But this improved performance typically is at the expense of higher tracking costs. Well-established, commercial CSP collector designs include parabolic troughs and heliostats. Linear Fresnel and parabolic dish collectors have also been demonstrated, albeit at a smaller scale. CSP collector costs (including direct, indirect and O&M costs) were estimated in 2013 to account for approximately 40% of the levelized cost of electricity (LCOE) of a CSP power tower plant.

This subtopic seeks applications that demonstrate novel collector designs that could significantly reduce the contribution of solar collectors to CSP plant cost and surpass the 2020 SunShot CSP cost targets. Such collector designs may include optical waveguides with minimal-to-no tracking and microfluidics. (Note that low cost CS collector designs are also of interest in the subtopic "Concentrating Solar Thermal Desalination".)

The performance of CSP collectors is intimately coupled to the type of thermal receiver and heat transfer fluid. Successful applicants must demonstrate ability to meet the 2020 SunShot technical and cost targets for the solar collector subsystem (http://energy.gov/eere/sunshot/collectors-rd-csp-systems) in concert with the thermal receiver targets (http://energy.gov/eere/sunshot/receiver-rd-csp-systems) and the heat transfer fluid targets (http://energy.gov/eere/sunshot/multidisciplinary-university-research-initiative-high-operating-temperature-fluids).

Questions – contact: solar.sbir@ee.doe.gov

c. Concentrating Solar Thermal Desalination

Competing demands for fresh water — among ecosystems, agriculture, municipalities, and industries — are affecting the value and availability of the critical fresh water resource. Three salt water desalination techniques are currently in use globally to produce fresh water from salt water at the industrial scale: reverse osmosis (RO), multi-stage flash distillation (MSF), and multi-effect distillation (MED). RO, the most widely deployed technique, filters water using a membrane to remove particulates. The major energy requirement is electricity to pump and pressurize the feed water. MSF thermally vaporizes salt water in a low-pressure chamber and directs the resultant steam into a collection reservoir where it is condensed. MSF plants require heat for creating the steam and electricity for pumping. MED is similar to MSF, but rather than a single low-pressure chamber, a series of chambers is utilized, each with a lower pressure than the preceding chamber. As with MSF, MED requires both thermal and electrical energy, but MSF has the advantage of being able to operate at a lower brine water temperature.

The industrial-scale and heat requirements of MSF and MED make concentrating solar thermal desalination a potentially value-adding, cost-reducing alternative to conventional sources of thermal energy for desalination. In addition, concentrating solar thermal MSF and MED systems use lower-cost renewable energy; have lower sensitivity to water salinity; can more easily operate off-grid; have reduced demand for high-value electricity; and produce less chemical waste than RO systems. However, large-scale solar thermal MSF and MED are approximately four times more expensive than RO (given a cost of nearly $\$2.00/m^3$ of fresh water).

This subtopic seeks to identify and invest in concentrating solar thermal MSF and MED technologies that can meet and beat RO desalination costs (~$\$0.50/m^3$ fresh water) by reducing the levelized cost of solar thermal energy (in terms of $\$/kWh_{th}$). By targeting a relatively low temperature output (<150°C for thermal desalination vs. >650°C for cost-effective solar electric power generation), ultra-low cost solar thermal collection strategies can reduce energy costs. Use of non-tracking collectors (to eliminate expensive drive/control mechanisms), low-cost materials (e.g. polymers), reduced site preparation (to enable rapid field construction), and integration with low-cost, low-temperature thermal energy storage, in addition to other innovations, could lower the cost of the heat input such that concentrating solar desalination can compete with RO desalination.

Questions – contact: solar.sbir@ee.doe.gov

d. Grid Performance and Reliability

The SunShot Systems Integration (SI) Grid Performance and Reliability activity area focuses on achieving high penetration of solar generation at both the transmission and distribution levels in a cost-effective manner, while ensuring safety and reliability of the grid. It is SunShot's intent to not only preserve but also enhance the performance and reliability of the entire power system operating with high penetration of solar generation. SunShot SI target metrics are as follows:

- High penetration of solar generation at levels greater than 100% of today's peak load
- Reduced interconnection approval time for solar projects to less than 1 week on average
- Reduced interconnection costs for solar projects to less than USD $1,000 on average
- Exceeding present and future ANSI, IEEE and NERC grid performance standards (http://grouper.ieee.org/groups/scc21/1547/1547_index.html)

Applications are sought for advanced methodology and software that will interface with existing utility legacy software and hardware systems to (i) aggregate, visualize, analyze and control multiple photovoltaic (PV) generation installations at the distribution feeder, substation and sub-transmission level in real-time; (ii) collect, analyze and process enormous and complex amount of feeder, load and PV data in real-time; (iii) quantify and analyze both positive and negative impacts of PV on the four distribution reliability metrics (System Average Interruption Duration Index (SAIDI),System Average Interruption Frequency Index (SAIFI), Customer Average Interruption Duration Index (CAIDI) and Average Service Availability Index (ASAI)) that are based on economic, technical and time series analysis; (iv) create engineering analysis tools for distribution planning and operation to pro-actively mitigate before a perturbation occurs, potential high PV penetration grid impacts; (v) provide a cloud-based "hub" for electric utilities to access the various advanced PV tools, PV engineering analysis best-practices, technical resources and reliability benchmarking; and (v) expedite the utility PV interconnection technical screening process and lower interconnection costs.

Applications are also sought for advanced open source tools that automate data exchange between PV and utility software systems and promote interoperability between existing utility legacy software and new systems. Emerging bulk transmission and dynamic open source distribution engineering analysis software, combined with innovative hardware systems for data acquisition, predictive analysis, and real-time visualization, enables the utility to quickly and effectively model aggregated potential high PV grid impacts, recommend mitigation solutions, and provide advanced capabilities for system planning and grid operations with high penetration of PV. With these innovative tools, utilities' concerns about the uncertainty of PV impact on the grid are significantly decreased, thereby allowing higher level of PV penetration to be integrated on the distribution system. In addition, these advanced tools can significantly enhance the utility distribution planning and operational capability, reduce the expensive interconnection study fees paid by developers, reduce turnaround time for initial determination, allow more PV installations to pass the interconnection screens, and ultimately expedite cost-effective deployment of PV generation on distribution and transmission systems.

Questions – contact: solar.sbir@ee.doe.gov

e. Labor Efficiencies through Hardware Innovations

Installing a photovoltaic (PV) system requires both electrician and non-electrician labor such as assembling the module, racking and mounting or ballasting it, running conduit, and connecting the inverter, meter, and disconnect. In the United States, PV installation is complicated by the heterogeneity of installation platforms, component materials, electric systems, and utility requirements making streamlining efforts more difficult. Optimizing system performance typically requires both a custom system design and a custom installation—each with added costs.

Applications are sought for hardware innovations that reduce installation labor costs** by increasing labor efficiency or reducing the process complexity required to install a PV system. Installation cost reduction opportunities include: (1) integrated racking, which reduces balance of system hardware; (2) module-integrated electronics, which reduces cable runs; (3) prefabrication, which streamlines installation; and (4) 1,000-volt direct current technologies, which enables more modules wired together per string. Successful applicants must quantify the achievable cost reductions and justify the economic viability of the proposed product assuming near term (<5 years) industry deployment. (**The SunShot Initiative targets a reduction in total commercial installation labor costs from $0.42/W in 2010 to $0.07/W by 2020; for residential systems, $0.59/W to $0.12/W, respectively).

Questions – contact: solar.sbir@ee.doe.gov

17. VEHICLES

Maximum Phase I Award Amount: **$150,000**	*Maximum Phase II Award Amount:* **$1,000,000**
Accepting SBIR Phase I Applications: **YES**	*Accepting SBIR Fast-Track Applications:* **NO**
Accepting STTR Phase I Applications: **YES**	*Accepting STTR Fast-Track Applications:* **NO**

EERE's Vehicle Technologies Office (VTO) (www1.eere.energy.gov/vehiclesandfuels/) focuses on reducing the cost and improving the performance of vehicle technologies that can reduce petroleum dependency, including advanced batteries, electric traction drive systems, lightweight materials, advanced combustion engines, and advanced fuels and lubricants. VTO supports the development and deployment of advanced vehicle technologies, including advances in electric vehicles, engine efficiency, and lightweight materials. Since 2008, the Department of Energy has reduced the costs of producing electric vehicle batteries by more than 35%. DOE has also pioneered better combustion engines that have saved billions of gallons of petroleum fuel, while making diesel vehicles as clean as gasoline-fueled vehicles.

Applications that duplicate research already in progress will not be funded; all submissions therefore should clearly explain how the proposed work differs from other work in the field.

Grant applications are sought in the following subtopics:

a. Electric Drive Vehicle Batteries

Applications are sought to develop electrochemical energy storage technologies which support commercialization of micro, mild, and full HEVs, PHEVs, and EVs. Some specific improvements of interest include, but are not limited to, the following: new low-cost materials; high voltage and high temperature non-carbonate electrolytes; improvements in manufacturing processes, speed, or yield; improved cell/pack design minimized inactive material; significant improvement in specific energy (Wh/kg) or energy density (Wh/L); and improved safety. Applications must clearly demonstrate how they advance the current state of the art and meet the relevant performance metrics listed at www.uscar.org/guest/article_view.php?articles_id=85.

When appropriate, technology should be evaluated in accordance with applicable test procedures or recommended practices as published by the Department of Energy (DOE) and the U.S Advanced Battery Consortium (USABC). These test procedures can be found at www.uscar.org/guest/article_view.php?articles_id=86. Phase I feasibility studies must be evaluated in full cells (not half cells) greater than 200mAh in size while Phase II technologies should be demonstrated in full cells greater than 2Ah. Applications will be deemed non-responsive if the proposed technology is high cost; requires substantial infrastructure investments or industry standardization to be commercially viable; and/or cannot accept high power recharge pulses from regenerative breaking or has other characteristics that prohibit market penetration. Applications deemed to be duplicative of research that is already in progress or similar to applications already reviewed this year will not be funded; therefore, all submissions should clearly explain how the proposed work differs from other work in the field.

Questions – contact: Brian Cunningham, brian.cunningham@ee.doe.gov

b. SiC Schottky Diodes for Electric Drive Vehicle Power Electronics

Power electronic inverters are essential for electric drive vehicle operation. DOE R&D targets and research pathways for inverters are described in both the U.S. DRIVE Partnership Electrical and Electronics Technical Team Roadmap [1] (http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/eett_roadmap_june2013.pdf) and EV Everywhere Blueprint [2] (http://energy.gov/sites/prod/files/2014/02/f8/eveverywhere_blueprint.pdf). These documents discuss both performance benefits of and the barriers (including high cost) — to high volume automotive adoption of wide bandgap (WBG) semiconductors. With large area (>150 mm, or 6”) SiC epiwafer is available from a large number of qualified suppliers. The SiC device industry is approaching the same cost-competitiveness as the silicon power device industry, where the cost of fabrication is the primary driver of device costs, and high device yield enables low overall device costs.

The devices that are best positioned to be an early adopter of these SiC epiwafers are SiC Schottky diodes, which offer 100X smaller on-state resistance as compared to Si and GaAs diodes and enable very high power density inverters for use in electric drive vehicles. The high switching speed of SiC diodes also provides significantly increased efficiencies for power inverter applications. While lower current (<50A) SiC Schottky diodes offered by a few SiC device suppliers have already penetrated solar and computer power supply manufacturers, higher, >100 A current remains a key threshold for automotive applications.

VTO seeks applicants to overcome this SiC device current threshold barrier by demonstrating production of >100A, >600V rated diodes suitable for use in electric-drive vehicle traction motor inverters. Specifically, devices produced should show automotive application readiness by passing qualification specifications or standards while achieving high yields. Where possible, applicants should show a relationship to, and demonstrate an understanding of automotive application requirements and environments. Example approaches for applicants include surface and/or substrate treatments and processing and compatibility with existing wire bond power module processing. Applications should also describe the cost of manufacturing SiC diodes compared to competing silicon diodes, including details such as costs and availability of commercial SiC substrates, epilayers, and additional equipment needed. Applications should link these costs to a commercially viable business model for scale up and increased production that could be executed in Phase II.

Questions – contact: Steven Boyd, steven.boyd@ee.doe.gov

c. Onboard Fuel Separator or Reformer

On-board fuel separation or reformation has the potential to overcome infrastructure (e.g. pipeline, dispenser material compatibility) and consumer challenges associated with introducing fuel streams with specific desirable characteristics, such as very high-octane or evaporative cooling capability, during vehicle operation. After overcoming such challenges, these fuel streams would be able to positively affect the combustion process and result in increased efficiency for automotive vehicles. On-board separation/reformation technologies, if successful, could accelerate the deployment of vehicles with more efficient combustion designs that require specific fuel streams characteristics during some driving modes.

The technology developed under this subtopic must be capable of separating or reforming convention fuels and be packaged on conventional light or heavy duty vehicles without disrupting the existing system. The developed prototype must be capable of demonstrating a net 10% fuel economy improvement, and cost to manufacture on a production basis must not exceed $200/unit.

Questions – contact: Roland Gravel, roland.gravel@ee.doe.gov

d. Alternative Crank Mechanisms for Internal Combustion Engines Leading to Improved Energy Efficiency

Reciprocating internal combustion (e.g. gasoline or diesel) engines for automotive applications use slider/crank mechanisms to create torque on an engine's output shaft from forces applied to pistons as a result of the pressure created by the combustion of fuel. While direct mechanical losses of traditional slider/crank mechanisms are small, there is another indirect loss as a consequence of slider/crank use. Early in an engine's power stroke, cylinder temperatures—and therefore convective and radiative heat losses—all peak. The engine's rate of performing work is still very low reducing energy efficiency. The net effect may be that slider/crank mechanisms indirectly lead to preventable energy losses and reduced energy efficiency.

Applications must propose the development of a functioning prototype of a mass-produced, commercially available reciprocating engine, modified with an alternative mechanical mechanism linking the piston to the engine's output shaft is desired. Reporting must include fuel consumption test results over the entire engine map of the prototype compared with a second, unmodified, otherwise identical engine. All fuel consumption testing must be conducted according to engine industry norms. Statistically valid fuel economy improvements (95% confidence level) of at least 5.0% are desired.

Questions – contact: Leo Breton, leo.breton@ee.doe.gov

e. Advanced Ignition System for Internal Combustion Engines Enabling Lean-Burn and Dilute Gasoline Ignition

Lean-burn combustion in gasoline (Otto-cycle) engines introduces physical conditions that severely impede reliable ignition of fuel-air mixtures.

For Phase I, prototype ignition systems are sought that:

1. Extend the lean ignition limit to an air/fuel ratio >20;
2. Enable reliable ignition under high in-cylinder pressures (up to 100 bar at the time of ignition), thus enabling high load operation;
3. Enable operation under high levels of exhaust gas recirculation; and
4. Lower or maintain ignitability as measured by a coefficient of variance of IMEP <3%.

Typical candidates for this effort are advanced ignition systems such as laser ignition, microwave ignition, and plasma jet ignition. Prechamber combustion systems are not of interest for this subtopic.

Questions – contact: Leo Breton, leo.breton@ee.doe.gov

References:

Subtopic b

1. *Electrical and Electronics Technical Team Roadmap.* (2013). U.S. DRIVE Partnership. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/eett_roadmap_june2013.pdf

2. *EV Everywhere Grand Challenge Blueprint. (2013).* United States Department of Energy. http://energy.gov/sites/prod/files/2014/02/f8/eveverywhere_blueprint.pdf

18. WATER

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

The Office of Energy Efficiency and Renewable Energy's Wind and Water Technology Office's Water Program seeks applications for innovation in small hydropower, marine, and hydrokinetic (MHK) technologies. The Water program (http://energy.gov/eere/water/water-power-program) researches, tests, evaluates, and develops innovative technologies capable of generating renewable, environmentally responsible, and cost-effective electricity from water resources. This includes hydropower, as well as marine and hydrokinetic energy technologies, which capture energy from waves as well as riverine, tidal, and ocean currents.

Grant applications are sought in the following subtopics:

a. Innovative Small, Low-head Hydropower Turbines

Almost 40GW of the undeveloped hydropower stream-reach resource potential identified by the Oak Ridge National Laboratory (http://nhaap.ornl.gov/sites/default/files/ORNL_NSD_FY14_Final_Report.pdf) may require turbine-generator units operating at less than 25 feet of head to be used.

Applications are sought for innovative small hydraulic turbine prototypes or integrated small hydropower turbine-generator unit prototypes that can generate from 50kW to 5MW power at heads less than 25 feet. Key areas of interest include advanced materials and manufacturing for powertrain components, innovative hydrodynamic and mechanical concepts to reduce machinery size, favorable efficiency over a range of head and flow rates, low initial cost, durability and ease of replacement. Proposed innovations should be amenable to scaling in the amount of head, flow, and power.
Questions – contact: Rajesh Dham, rajesh.dham@ee.doe.gov

b. Prognostic & Health Monitoring of MHK devices

Commercial-scale marine and hydrokinetic (MHK) energy converters are large, often highly dynamic devices operating in a harsh marine environment. Servicing these devices at sea is a difficult and costly operation. As such, minimizing the maintenance frequency and failure frequency of these devices has the potential to reduce the MHK levelized cost of energy. Prognostic and health monitoring (PHM) systems anticipate and identify relevant changes to device health, informing optimal maintenance schedules and issuing warnings and alarms which may then inform human operators, initiate alternate device dynamic control sequences, and/or initiate the device survival mode; mitigating damage to the devices and maximizing availability.

Grant applications are sought for innovative PHM systems optimized for use in tidal, current, wave, and/or ocean thermal energy converters. Successful applications must propose methods and technologies to identify and monitor modes of fault/failure specific to an archetypal MHK device (e.g.

point absorber, axial flow turbine), specify the anticipated interaction of the PHM system with the control and survivability modes of the device, and outline plans to assess the market potential of the system. PHM methods and technologies which are broadly applicable across MHK energy converters are strongly encouraged.

Questions – contact: Rajesh Dham, rajesh.dham@ee.doe.gov

References:

Subtopic a

1. S. Kao, et al. (2014). *New Stream-reach Development: A Comprehensive Assessment of Hydropower Energy Potential in the United States.* Prepared by Oak Ridge National Laboratory for the United States Department of Energy Wind & Water Power Technologies Office. http://nhaap.ornl.gov/sites/default/files/ORNL_NSD_FY14_Final_Report.pdf

19. WIND

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

The Office of Energy Efficiency and Renewable Energy's Wind Program, part of the Wind and Water Power Technologies Office (www.eere.energy.gov/wind/), seeks applications for innovations that significantly advance the goal of large cost reductions in the deployment of U.S. wind power resources by exploring technologies that enable the production of larger wind turbine rotors through active load alleviation.

Grant applications are sought in the following subtopic:

a. Active Load Alleviation Strategies for Wind Turbine Blades

There has been an increasing trend among wind turbine Original Equipment Manufacturers (OEMs) to increase the length of the rotor blades to allow wind plants to operate economically in the low wind speed sites around the world. While a larger rotor for a given MW rating can increase the capacity factor of the plant, the design of such a rotor is challenging. To keep costs down, transportation logistics, manufacturing constraints, and turbine design load constraints must all be addressed effectively. Recently, turbine designers have adopted passive load alleviation strategies that allow them to increase the length of the blades without incurring severe weight penalties.

The Wind program, strategy, in this topic, is to focus on *active* control strategies to manage and mitigate loads experienced by the turbine within its design envelope. While active load alleviation holds the promise of being more versatile than passive strategies, it is also inherently more risky. Significant R&D issues such as fatigue leading to increased maintenance/repair and reduced reliability, must be addressed before these technologies will be accepted by turbine manufacturers and integrated into the next generation of large wind turbine blades to become part of their product offering.

A new generation of active load control strategies that can be economically manufactured and integrated into turbine blades could significantly increase wind deployment at low wind speed sites. Grant applications are sought for innovative active wind turbine blade load alleviation concepts with the potential to serve as competitive alternatives to current passive load alleviation strategies. Successful applications must develop, mature, and de-risk the technology to the point that it is ready to be integrated into a turbine blade design. Applicants must identify and solve problems related to manufacturing, integration into the blade manufacturing process, reliability of the technology, routine maintenance and repair.

Questions – contact: Shreyas Ananthan, shreyas.ananthan@ee.doe.gov

PROGRAM OFFICE OVERVIEW – OFFICE OF FOSSIL ENERGY

DOE's Office of Fossil Energy (FE) is responsible for several high-priority initiatives including implementation of the Clean Coal Power Initiative to develop a new generation of environmentally sound clean coal technologies as well as innovations in oil and natural gas technologies to recover oil, natural gas, methane hydrates, and shale gas still obtainable from the Nation's conventional oil reservoirs and/or from non-conventional sources.

Fossil fuels are projected to remain the mainstay of energy consumption (currently 80% of U.S. energy consumption) well into the next century. Consequently, the availability of these fuels, and their ability to provide clean affordable energy, is essential for global prosperity and security. As the nation strives to reduce its reliance on imported energy sources, FE supports R&D to help ensure that new technologies and methodologies will be in place to promote the efficient and environmentally sound use of America's abundant fossil fuels. As the economy expands, and the demand for hydrocarbons increases accordingly, FE seeks to develop advanced fossil energy technologies that are reliable, efficient, environmentally sound and economically competitive.

For additional information regarding the Office of Fossil Energy priorities, click here.

20. CLEAN COAL AND CARBON MANAGEMENT

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

For the foreseeable future, coal will continue to play a critical role in powering the Nation's electricity generation, especially for base-load power plants. Coal-fired power plants have made significant progress in reducing emissions of sulfur dioxide (SO_2), nitrogen oxide (NOx), particulate matter (PM), and recently mercury (Hg), since the passage of the Clean Air Act. Recently proposed limits on CO_2 emissions from new electric generating units will require carbon capture on any new coal-fired power plant. To prepare for upcoming regulations, significant research and development is currently being pursued for new technologies to capture carbon from flue gas streams produced by coal-fired electric generating power plants. In addition, the Office of Fossil Energy (FE) is developing a new generation of clean coal-fueled energy conversion systems capable of producing competitively priced electric power while reducing CO_2 emissions, with a focus on improving efficiency, increasing plant availability, reducing cooling water requirements, and achieving ultra-low emissions of traditional pollutants. A key aspect of this area of research is targeted at improving overall system thermal efficiency, reducing capital and operating costs, and enabling affordable capture. FE also continues to support research that ensures that CO_2 can be safely and permanently stored in geologic formations in a process known as carbon storage.

Particular attention will be focused on finding new ways to extract the power from coal – while simultaneously expanding environmental protection and confronting the issue of global climate change. Key R&D programs include: (1) Crosscutting research including advanced materials manufacturing; and innovative concepts for water sensors, aiming to make these technologies commercially competitive. (2) Advanced energy systems for future coal-based power plants including developments in the application of computational fluid dynamics and advanced manufacturing related to reactor geometry design; solid separation of contaminants from sorbents in advanced combustion applications; improved bearings and seals for supercritical CO_2 power cycles for turbine applications; and protective coatings for solid oxide fuel cells balance of plant components; (3) Carbon capture research including transformational technologies for process intensification aimed at reducing cost and improving performance of carbon capture in advanced power systems; and application of nano-engineered materials and advanced microscale manufacturing. (4) Carbon storage including cost effective technologies and equipment to measure in-situ geomechanical properties; and advanced monitoring technologies.

Grant applications are sought in the following subtopics:

a. Advanced Materials Manufacturing (Crosscutting Research)

The severe operating environments (high temperature, pressure, and corrosivity) and performance specifications of advanced FE systems will require that components and subassemblies be fabricated from increasingly complex and expensive materials. Traditional manufacturing process methods are not always efficient in the production of these highly specialized components. The use of advanced manufacturing (AM) techniques (such as additive manufacturing) can be used to improve, enhance, and/or eliminate industrial fabrication process steps in a manner that achieves reduced material usage and lower cost. Examples of advanced manufacturing for process intensification include 3D printing technology to produce wax models for investment casting and use of directly built additive manufacturing cans for hot isostatic pressing of powdered metal (HIP/PM).

Fabrication of individual components and subassemblies for FE power generation systems may also require welding or other high temperature joining processes such as diffusion bonding and brazing. The joining of advanced materials for use in harsh FE environments, including the joining of dissimilar materials such as metal-to-ceramic interfaces, introduces an additional level of technical design and manufacturing complexity. Conventional fusion welding of many creep resistant alloys results in significant reduction in weld creep strength, even with expensive post weld heat treatments. Early weld failure has been a major issue for a number of creep strength enhanced ferritic steels used in FE power plants.

Applications are sought for advanced fabrication and processing techniques which can address these problems. Novel and more robust ways to manufacture, conduct process intensification, and/or join semi-finished and finished components and subassemblies for advanced fossil energy applications are sought. These methods must offer the potential to reduce manufacturing costs, improve product recovery, reduce product variability, and/or allow the production of more precisely designed structural and functional materials. Proposals should specify a particular component or system that is relevant to

FE power generation and discuss the challenges associated with traditional manufacturing for the intended application. The applicant should then discuss how their proposed method could improve on the current state of the art.

Questions – contact: Richard Dunst, richard.dunst@netl.doe.gov

b. Integrated Sensors for Water (Crosscutting Research)

One of the drivers in effectively managing water is the need for reliable, real-time, measurement-based data. The development of sensors that are inexpensive, self-powered, rapidly deployable, robust, and wireless would facilitate the requisite data collection. Currently, a network of widely deployable, integrated water sensors is expensive which inhibits the utilities' ability to deploy such sensors. This results in the need for predictions and estimates for water management information because little actual data is collected. The present and growing emphasis on reducing or maintaining the water-use footprint in the energy sector should not move forward based on projections and estimates alone, but from tangible, collected data.

Grant applications are sought for the development of an integrated water sensor package that is low-cost, rapidly-deployable, wireless, and self-powered while making and relaying in situ water measurements such as temperature, turbidity, flow, pH, and total dissolved solids (TDS.) Other key indicators of water quality and condition can be considered but relevance of the measurement must be justified. Preference will be given to integrated sensor packages that make multiple measurements for the lowest cost. The aim is to measure constituents that are a problem in the water arena such as the eight Resource Conservation and Recovery Act (RCRA)-monitored heavy metals, known as the RCRA 8s, salts, scale forming minerals, and naturally occurring radioactive materials (NORM) in a fully-integrated sensor package that must be able to survive the ambient environment within water treatment facilities or bodies of water associated with power generation facilities.

Approaches that do not address all facets of this integrated sensor package are not of interest for this subtopic and will be declined.

Questions – contact: Jessica Mullen, jessica.mullen@netl.doe.gov

c. Unique Reactor Geometry for Ideal Gas-Particle Contacting (*AES-Gasification)

Current reactor design is based on a long legacy of industrial use. Anecdotal experience has led to incremental advancements in the simplistic geometries employed, typically spheres and cylinders.

However, advanced manufacturing has the ability to allow complex geometries to be feasible at economical costs and to accelerate the pace of progress towards that goal, and Computational Fluid Dynamics (CFD) modeling has become increasing powerful tool. The purpose of this topic is to explore the possibilities inherent in Advanced Manufacturing and CFD models to re-define the boundaries of what a reactor can be, and apply industrial constraints (temperature, pressure, particle size limits, etc.) later.

The DOE is interested in proposals to develop and test a protocol for creating unique reactor geometries with significantly improved gas-particle contacting over current industrial reactors, and that have credible potential of being useful at industrial scale (this being based on particle-gas flow behavior and not on materials of reactor manufacture, which is itself a rapidly evolving science). The protocol would use a combination of technologies to explore the most promising configurations by:

Identifying unique reactor geometries using advanced CFD that would represent significant gas-particle contacting improvements. CFD modeling would be limited to the use of open source code, such as MFIX or OpenFoam.
Designing and constructing at least one cold-flow prototype of the reactor to validate computational models. The prototype must be fabricated using 3D printing, or a similar advanced manufacturing process, to enable reduced cost, increased fabrication speed and increased feasible reactor complexity.
Running tests using at least one cold-flow prototype and comparing particle-gas contacting results to the CFD model predictions.

Questions – contact: David Lyons, k.lyons@netl.doe.gov

d. Bearings and Seals for Supercritical CO_2 Power Cycles (*AES-Turbines)

Supercritical CO2 (SCO2) power cycles are gaining significant interest for multiple power generation applications. These power systems will be supported by a crosscutting effort in Energy Efficiency and Renewable Energies (EERE) and Nuclear Energy (NE) in addition to Fossil Energy (FE). The reason Supercritical SCO2 cycles have gained such interest is they are anticipated to achieve higher efficiencies than steam-based Rankine cycles at turbine inlet temperatures greater than 550°C. References show that 50% thermal-to-electric conversion efficiency can be achieved from SCO2 power cycles having turbine inlet temperatures exceeding 700°C. Operating at pressures as high as 30 MPa, a significant barrier to the commercialization of these power cycles is the need for bearings and seals capable of operating at these high pressures and temperatures.

Grant applications are sought for the research and development of bearings and seals compatible with SCO2 at pressures as high as 30MPa and temperatures exceeding 700°C for axial turbomachinery. Externally pressurized gas bearings in turbomachinery could eliminate oil bearings and many associated sealing requirements. These bearings would require high temperature materials to operate in SCO2 above 700°C and would enable sealed turbomachinery more conveniently and affordably than the current state of the art. The literature suggests that dynamic seals such as dry gas seals or leaf seals will be required in SCO2 power cycles greater than 10 MWe. Dynamic seals are commercially available for the required pressure, but are limited to low temperature small diameters. Applications are sought for bearings and seals capable of transient and steady operation in utility scale configurations while handling thermal loads from the SCO2 working fluid at temperatures as high as 800°C. A complete description of the manufacturing process required to achieve the proposed architectures should be provided to facilitate analysis of potential cost entitlements and implementation complexity.

Questions – contact: Seth Lawson, seth.lawson@netl.doe.gov

e. Solid Separation Technology Enabling Sorbent Reuse in Fossil Energy Combustion Applications (*AES Advanced Combustion)

A large segment of fossil energy power generation applications, both conventional and advanced, require injection of particulate sorbents and/or oxygen carriers for successful process operations. Examples include conventional Fluidized Beds Combustors (FBC), Oxygen-fired Pressurized Fluidized Bed Combustors (Oxy-PFBC), and Chemical Looping Combustion (CLC). In FBCs and Oxy-PFBCs, limestone is typically injected for sulfur removal and expelled from the system as a by-product. In CLC, a similar interaction between the oxygen carrier particles and fuel based contaminants can occur. In each case, the net result is that sorbents/carriers are intermingled with contaminants leaving the system that subsequently require landfill disposal.

An opportunity exists to separate the fuel-based contaminants (e.g. char & ash) from sorbents/carriers for beneficial reuse and recycling. Contaminant-free sorbents/carriers may be sold for industrial purposes such as manufacturing wallboard or cement. In other cases, the contaminant-free sorbents/carriers may be reused within the systems themselves. In all cases, landfill disposal costs would be decreased.

Grant applications are sought for technologies suitable for the separation of solid sorbent/oxygen carrier particles from solid coal contaminants. Examples could include but are not limited to: ash separation and unconverted char separation technologies amenable to by-product or recycling streams from fossil energy combustion applications.

Questions – contact: Steven Richardson, steven.richardson@netl.doe.gov

f. Protective Coatings for Solid Oxide Fuel Cell (SOFC) Balance-of-Plant Components (*AES-Fuel Cells)

Stainless steels commonly used in SOFC thermal and cathode air management subsystems, upon exposure to high-temperature (maximum temperature of 700°C to 900°C, depending upon the specific system configuration and SOFC technology) humidified air, evolve Cr vapor species which poison SOFC cathodes, degrading electrochemical performance. Low-cost alloys and/or coating systems for these hot balance-of-plant (BOP) components are desired to reduce or eliminate Cr species evolution, resulting in a lower capital cost and improved life of SOFC power generation systems. Grant applications are sought to evaluate candidate alloys and/or protective coatings for this application. Evaluation activities should include, at a minimum, performance (including Cr species evolution) under high-temperature, atmospheric humidity conditions and production/processing cost at high volume. Approaches of interest include but are not limited to:

Identify or develop low-cost stainless steel alloys and/or coatings suitable for cathode-side hot piping and/or heat exchangers. The approach should include a baseline material (cost, life requirement, fabrication/manufacturability issues, etc.) for reference purposes.

Identify or develop lower-cost slurry/spray-based coatings interior surfaces (piping with joint welds, baffles, etc.) and irregular geometries, having Cr-volatility mitigation as effective as industrial pack cementation and vapor coatings.

Questions – contact: Steve Markovich, steven.markovich@netl.doe.gov

*AES: Advanced Energy Systems

g. Process Intensification for Carbon Capture Systems

Application of Process Intensification to Carbon Capture Systems: Processes being developed for CO2 capture employ a number of standard unit operations, such as gas-liquid contactors (e.g., gas absorbers and strippers), gas-solid contactors (e.g., packed and moving beds), gas-separation membranes, heat exchangers, pumps, and compressors; all of which may be suitable for process intensification, by integrating two or more of these operations within a single piece of equipment. Example combinations include absorption/desorption, adsorption/desorption, compression/gas separation, and membrane reactors.

DOE has on-going projects for CO2 capture focused on the development of absorption systems employing liquid solvents, adsorption systems employing solid sorbents, and gas-separation membrane systems. Applicants are encouraged to focus their proposals toward development and/or testing of optimized hybrid and/or integrated approaches that synergistically complement each other to significantly improve the performance and lower the costs of carbon capture. New solvent, sorbent, or membrane materials development should not be a part of any proposal submitted and will be considered non-responsive to the sub-topic.

Questions – contact: Andy Aurelio, isaac.aurelio@netl.doe.gov

h. Materials Engineering for Carbon Capture

Application of Nano-engineered Materials and Advanced Microscale Manufacturing to Carbon Capture Systems: Developments in the field of nano-engineering have resulted in the discovery of a number of new and novel materials which may have beneficial applications for CO2 capture. Nano-materials can possess precise dimensions and functionalization ideally suited for CO2 capture. Therefore, they can be used as materials in the manufacture of size- and species-selective gas-separation membranes with extremely-high permeance, solid sorbents with extremely-high volumetric capacities, heat and mass transfer media with extremely high surface areas and transfer rates, and catalysts with extremely high rates of reaction.

Focus of the proposed research should be on application of these types of engineered materials to gas separation for CO2 capture and improved heat and mass transfer in CO2 capture systems.

Questions – contact: Andy Aurelio, isaac.aurelio@netl.doe.gov

i. Advanced Geologic Storage Technologies

DOE is the lead agency supporting research and development of technologies to ensure that greater than 99% of injected CO_2 remains permanently stored in deep geologic formations. Carbon storage research conducted in the near and long term will augment existing technologies to ensure permanent storage of CO_2 for the emerging CO_2 storage industry. The program supports research that will improve the nation's scientific understanding in six key technologies: wellbore integrity; potential leakage mitigation; fluid flow, pressure, and water management; geomechanical impacts; geochemical impacts; and risk assessment. The importance of obtaining accurate geomechanical information related to storage sites has been cited in numerous publications. Specifically, there is a need to understand the potential for geomechanical deformation to the injection zone, confining zone, and wellbore as a result of CO_2 injection. Such impacts may include induced seismicity, faulting, fracturing, and damage to wellbore materials. Geomechanical information obtained at one CCS project may be applied to other projects and used for detecting subsurface geomechanical changes, tracking fluid movements, and can lead to better injection management practices. Combining microseismic and geomechanical observations is very important to determine storage integrity.

Grant applications are sought for cost effective technologies and equipment that can measure in-situ geomechanical properties. The primary purpose of these technologies is to measure the in-situ state of stress, and geomechanical properties of the reservoir rock, seals, faults and fractures. Any in-situ technology or equipment should be compatible with the subsurface environment (geology, pressure, temperature, CO_2, saline waters, and petroleum hydrocarbons) at depths greater than 3,000 feet. It is envisioned that these geomechanical technologies may be utilized both pre-injection and post-injection. Proposals are sought that focus on developing new, or enhancing existing, geomechanical technologies and equipment to measure the in-situ state of stress, and geomechanical properties of the reservoir rock, seals, and faults and fractures. Preference will be given to technologies that demonstrate enhanced performance and permanence at reduced cost as well as the ability to collect geomechanical measurements between wellbores.

Approaches in developing new or enhancing existing modeling technologies or seismic processing techniques are not of interest for this subtopic. Grant applications using these approaches will not be responsive to the topic.

Questions – contact: Brian Dressel, brian.dressel@netl.doe.gov

j. Advanced Monitoring Technologies for Carbon Storage

A "Monitoring Verification and Accounting (MVA)" program is designed to confirm permanent storage of carbon dioxide (CO_2) in geologic formations through monitoring capabilities that are reliable and cost effective. Monitoring is an important aspect of CO_2 injection, since it serves to confirm storage permanence. Monitoring technologies can be developed to ensure that injection, abandoned, and monitoring wells are structurally sound and that CO_2 will remain within the injection formation. Operating permits under the Safe Drinking Water Act and Clean Air Act for geologic storage projects require monitoring to account for CO_2 that has been stored underground to ensure that potable groundwater sources and sensitive ecosystems are protected and to account for the CO_2.

Grant applications are sought for technologies involving field-based MVA hardware that measure the potential impacts of CO_2 on groundwater and the soil in the unlikely event that CO_2 migrates out of the injection zone. Proposals are sought that focus on developing new, or enhancing existing, MVA techniques and technologies for monitoring the detection of CO_2 in near-surface subsurface environment that can cover a large area with improved accuracy, continuous (real-time) monitoring capabilities, and long-term durability. Near-surface subsurface monitoring is defined as from the top of the soil zone down to the shallow groundwater zone.

Preference will be given to technologies that demonstrate enhanced performance at reduced cost. Approaches in developing new or enhancing existing modeling technologies are not of interest for this subtopic. Grant applications using these approaches will not be responsive to the topic.

Questions – contact: Erik Albenze, erik.albenze@NETL.DOE.GOV

k. Other

In addition to the specific subtopics listed, FE invites grant applications in other areas that fall within the scope of the higher level topic description provided above.

Grant applications must include a succinct discussion of the potential technical and economic advantages of the proposed technology, as compared to existing state-of-the-art systems.

Questions – contact Maria Reidpath, maria.reidpath@netl.doe.gov

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21. OIL AND NATURAL GAS TECHNOLOGIES

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

While crude oil and condensate production from shale formations is increasing rapidly in the U.S., operators are recognizing that the percentage of oil-in-place that will ultimately be recovered from these unique reservoirs will likely be significantly less than the recoveries historically achieved from more conventional reservoirs. The same appears to be true for shale gas plays being developed via horizontal wellbores with multiple hydraulic fracture treatments, where recoveries of perhaps 25% or less of the gas originally in place are being forecast.

DOE is interested in catalyzing the development of novel technologies that will improve the ultimate recovery of domestic oil and natural gas resources in an environmentally safe manner. Specifically, DOE is interested in funding the development of technologies that are focused on increasing the percentage of oil-in-place recovered from either conventional or shale reservoirs, or the percentage of gas-in-place recovered from shale reservoirs.

In addition, DOE is interested in funding research that can help companies more effectively monitor the topographical changes associated with drilling pad and pipeline right of way construction, and take prompt and effective action to mitigate any environmental impacts associated with these changes. Beyond-state-of-the-art research that can have (or lead to) "game-changing" impacts on recovery or environmental impacts will be considered more responsive to this solicitation than research that proposes small, incremental advances.

It should be noted that DOE is not interested at this time in grant applications related to research focused on oil shale deposits (i.e Green River formation) or oil sands deposits, but rather research related to shale oil (crude oil or condensate found in shale formations similar to but not limited to the Bakken, Eagle Ford, and the Niobrara). It should also be noted that DOE is not interested at this time in grant applications related to research focused on water treatment technologies, or in grant applications to perform computer modeling that is not part of a proposal with a significant laboratory or field research component.

Grant applications are sought in the following subtopics:

a. Improving Hydrocarbon Recovery from Shale Reservoirs

This subtopic focuses on increasing the portion of natural gas-in-place or oil-in-place in shale reservoirs that can be economically produced via horizontal, hydraulically fractured wells.

Specific subtopic technology interests include:

- Tools or methods for maximizing natural gas and/or oil recovery from shale reservoirs through improved well completion designs, operating procedures or field development practices. (e.g., EQT, see references below)
- Methods that advance the economic application of non-water-based fracturing fluids (e.g., LPG, LNG, natural gas or other novel fluids), either independently or in conjunction with water, in ways that serve to increase ultimate recovery of natural gas and/or oil from shale reservoirs (e.g. GASFRAC, see reference below)

- Advanced formation evaluation tools or techniques or perforation selection strategies that increase the efficiency of recovery on a per well basis (e.g., AOGR article, Schlumberger paper, see references below)

Grant applications must include a succinct discussion of the potential technical and economic advantages of the proposed technology, as compared to existing state-of-the-art systems. Proposals to fund the development of new (or modification of existing) hydraulic fracturing or reservoir simulation models will be considered less responsive to the priorities of this solicitation than proposals to fund the development of tools or the demonstration of operating technologies.

Questions – contact: Albert Yost, albert.yost@netl.doe.gov

b. Improving Methods for Remote Monitoring of Topographic Changes Resulting from Shale Play Development

This topic focuses on the development and/or testing of technologies, tools or methods for cost-effective aerial (or other remote) assessment and monitoring of topographic changes over time, resulting from well pad, road, or pipeline right-of-way construction. Specifically, the challenge is to develop a relatively low cost method for identifying, in a near-real-time manner, evidence of erosion, stream sedimentation, or other surface activities that require timely mitigation. See references (ESA, ISPRS) as examples of possible (but not the only possible) technologies for adaptation to low-cost applications.

Questions – contact: Albert Yost, albert.yost@netl.doe.gov

c. Other

In addition to the specific subtopics listed, the Department invites grant applications in other areas that fall within the scope of the higher level topic description provided above.

Grant applications must include a succinct discussion of the potential technical and economic advantages of the proposed technology, as compared to existing state-of-the-art systems.

Questions – contact: Albert Yost, albert.yost@netl.doe.gov

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PROGRAM AREA OVERVIEW – OFFICE OF FUSION ENERGY SCIENCES

The Department of Energy sponsors fusion science and technology research as a valuable investment in the clean energy future of the nation and the world, as well as to sustain a field of scientific research - plasma physics - that is important in its own right and has produced insights and techniques applicable in other fields of science and industry. The Fusion Energy Sciences (FES) mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished by studying plasma and its interactions with its surroundings across wide ranges of temperature and density, developing advanced diagnostics to make detailed measurements of its properties and dynamics, and creating theoretical and computational models to resolve the essential physics principles. FES has four strategic goals:

- Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source;
- Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment;
- Pursue scientific opportunities and grand challenges in high energy density plasma science to better understand our universe, and to enhance national security and economic competitiveness, and;
- Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic competiveness and to create opportunities for a broader range of science-based applications.

This is a time of important progress and discovery in fusion research. The U.S. has joined an international consortium (consisting of the European Union, Japan, China, Russia, Korea, and India) to fabricate and operate the next major step in the fusion energy sciences research program, a facility called "ITER. The purpose of ITER is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes. Experimental operations are planned to begin in approximately 10 years and are expected to continue for 20 years, demonstrating production of at least 10 times the power used to heat the fusion fuel and providing a platform to validate proposed commercial-grade technologies needed for power production.

The FES program is making great progress in understanding turbulent losses of particles and energy across magnetic field lines used to confine fusion fuels, identifying and exploring innovative approaches to fusion power that may lead to more economical power plants and encouraging private sector interests to apply concepts developed in the fusion research program. The following topics are restricted to advanced technologies and materials for fusion energy systems, fusion science, and technology relevant to magnetically confined plasmas, high energy density plasmas and inertial fusion energy, and low-temperature plasmas, as described below.

For additional information regarding the Office of Fusion Energy Sciences priorities, click here.

22. ADVANCED TECHNOLOGIES AND MATERIALS FOR FUSION ENERGY SYSTEMS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

An attractive fusion energy source will require the development of superconducting magnets and materials as well as technologies that can withstand the high levels of surface heat flux and neutron wall loads expected for the in-vessel components of future fusion energy systems. These technologies and materials will need to be substantially advanced relative to today's capabilities in order to achieve safe, reliable, economic, and environmentally-benign operation of fusion energy systems. Further information about research funded by the Office of Fusion Energy Sciences (FES) can be found at the FES Website, http://www.science.energy.gov/fes.

Grant applications are sought in the following subtopics:

a. Plasma Facing Components

The plasma facing components (PFCs) in energy producing fusion devices will experience 5-15 MW/m2 surface heat flux under normal operation (steady-state) and off-normal energy deposition up to 1 MJ/m2 within 0.1 to 1.0 ms. Refractory solid surfaces represent one type of PFC option. These PFCs are envisioned to have a refractory metal heat sink, cooled by helium gas, and a plasma facing surface, consisting of an engineered refractory metal surface or a thin coating of refractory material that minimizes thermal stresses. The materials being considered include tungsten alloys. Grant applications are sought to develop: (1) innovative tungsten alloys having good thermal conductivity , resistance to recrystallization and grain growth, good mechanical properties (e.g., strength and ductility), and resistance to thermal fatigue; (2) coatings or bulk specialized low-Z materials for improved plasma performance; (3) innovative refractory-metal heat sink designs for enhanced helium gas cooling; (4) efficient fabrication methods for engineered surfaces that mitigate the stresses due to high heat flux; and (5) joining methods, for attaching the plasma facing material to the heat sink, that are reliable, efficient to manufacture, and capable of high heat transfer – these new joining techniques may be applicable to either advanced, helium-cooled, refractory heat sinks or present-day, water-cooled, copper-alloy heat sinks.

Another PFC option is to use a flowing liquid metal surface as a plasma facing component, an approach which will require the production and control of thin, fast flowing, renewable films of liquid lithium, gallium, or tin for particle control at diverters. Grant applications are sought to develop: (1) techniques for the production, control, and removal of flowing (velocity 0.01 to 10 m/s) liquid metal films (0.5-5 mm thick) over a temperature controlled substrate; (2) advances in materials that are wetted by liquid metals at temperatures near the respective metal melting point and that are conducive to the production of uniform well-adhered films; (3) techniques for active control of liquid metal flow and stabilization in the presence of plasma instabilities (time and space varying magnetic field).

Questions – contact: Pete Pappano, peter.pappano@science.doe.gov

b. Blanket Materials and Systems

This topic seeks to address the challenges in harnessing fusion power, and developing the fusion fuel cycle technology through an advanced breeding blanket, which is designed to breed, extract, and process the nuclear fuel and heat energy necessary for a self-sufficient, electricity-generating reactor. The blanket is a complex, multi-function, multi-material engineered system (structure, breeder, multiplier, coolant, insulator, tritium processing), with many scientific and technological issues in need of resolution. Proposals are requested that address the following issues that include but are not limited to:

- Innovative solid fusion breeder fuel materials development and simulation tools;
- Innovative liquid fusion breeder and/or coolant materials development and simulation tools;
- Advanced materials and tools for simulation and analysis of breeder blanket material and component behavior in the fusion nuclear environment including thermofluid, MHD, and thermomechanical simulation of coolant flows and structural responses;
- Innovative materials and tools for simulation and analysis of materials and systems for tritium processes including creation, extraction, separation, purification, management and containment;
- Diagnostic sensors for blanket systems that are compatible with the fusion environment;
- Neutronic simulation and analysis tools that go beyond the current state of the art.

More detail on the topics of interest follow:

Solid breeder material concepts that advance as many as possible of the following criteria: (1) high breeder material densities (up to~80%); (2) high thermal conductivities (as opposed to point contacts between pebbles); (3) better thermal contact, such as reliable joined contact, with cooling structures (instead of point contacts between pebbles and wall); (4) the absence of major geometry changes between beginning-of-life and end-of life (such as sintering in pebble beds) in the presence of high neutron fluence; (5) structural integrity in freestanding and self-supporting structures with significant thermo-mechanical flexibility; (6) high breeding ratios that benefit from increased breeder and multiplier material densities (typically lithium and beryllium) and preferably leverage existing R&D in nano and micro engineered materials, such as those developed for advanced lithium ion batteries; and tools for simulation and analysis of materials and systems for solid breeders that leverage advanced computational techniques.

New liquid breeder material concepts that advance as many as possible of the following criteria: (1) new liquid breeder materials that have a high breeding capacity; (2) that are not influenced by the magnetohydrodynamic (MHD) effect; (3) can operate at high temperatures (400-700 deg C); (4) are not corrosive to the materials used in planned fusion systems (RAFM steels, ODS steels, NFAs, SiC); (5) are conducive to tritium extraction, and tools for simulation and analysis of materials and systems for liquid breeders that leverage advanced computational techniques.

Innovative materials and tools for solving specific challenges, such advanced simulation and analysis tools for thermofluid, MHD, and thermomechanical coolant flows and material responses. Also insulating the flowing liquid metal breeder/coolant against MHD and thermal effects with Flow Channel Inserts (FCI). These materials have a low electrical conductivity (1 to 50 Ω-1m-1). FCI structural loading is low, but they must be able to withstand radiation damage and thermal stresses from through-surface temperature differences in the range of 150-300K, over a thickness of 3 to 15 mm depending on designs.

Materials, simulations and tools needed for managing tritium used in the fusion fuel cycle in a safer and more efficient manner are needed. Early experiments can be performed using hydrogen as a surrogate, but more advanced technology development will likely need to be partnered with a national laboratory with the ability to handle tritium. Current solid breeders operate with a He purge gas at approximately 8 MPa, and liquid metal breeders at a partial pressure of approximately 0.3 Pa. Tritium extraction technologies including permeator materials and extraction methods need to distinguish between the different species for more efficient trapping and desorption from the He purge gas that operate at better than 40% efficiency on the first pass. An advanced purification system to remove impurities at better than 90% efficiency on the first pass is needed along with tritium barrier and management materials. An integrated multi-physics simulation tool to model tritium chemistry, tritium transport through materials, permeation rates, tritium concentration and flux in materials and systems, at different irradiation levels which goes beyond the current state of the art available domestically and internationally.

Diagnostics for the blanket system are needed, including liquid metal flow sensors that are able to accurately measure the velocity profile across the whole cross-section, and tritium concentration sensors.

Neutronic and safety simulation and analysis tools for determining radiation-induced material damage, tritium breeding efficiency, and worker radiation exposure conditions under a fusion environment with a peak 14 MeV neutron source are needed. The fusion neutronic environment is different, and harsher than the fission environment. Simulation and analysis tools that advance the state of the art to enable effective prediction of the fusion Tritium Breeding Ratio (TBR), material damage effects, such as swelling and creep, and prediction of the effectiveness of fusion radiation shields and barriers designed to limit worker and remote handling equipment exposure to the radiation environment, are critical to the safe adoption of fusion power. Ideally these tools are plug-ins, or compatible modules within existing commercial design software codes for structural, thermal, fatigue, or fluid flow, or safety analyses, such as Ansys®, Fluent®, Nastran®, LS-DYNA®, to enhance the integration, validation, and adoption of the tools.

Questions – contact: Edward Stevens, edward.stevens@science.doe.gov

c. Superconducting Magnets and Materials

New or advanced superconducting magnet concepts are needed for plasma fusion confinement systems. Of particular interest are magnet components, superconducting, structural and insulating materials, or diagnostic systems that lead to magnetic confinement devices which operate at higher magnetic fields (14T-20T), in higher nuclear irradiation environments, provide improved access/maintenance or allow for wider operating ranges in temperature or pulsed magnetic fields.

Grant applications are sought for:

Innovative and advanced superconducting materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs. Of specific interest are materials such as YBCO conductors that are easily adaptable to bundling into high current cables carrying 30-60 kA. Desirable characteristics include high critical currents at temperatures from 4.5 K to 50 K, magnetic fields in the range 5 T to 20 T, higher copper fractions, low transient losses, low sensitivity to strain degradation effects, high radiation resistance, and improved methods for cabling tape conductors taking into account twisting and other methods of transposition to ensure uniform current distribution.

Novel methods for joining coil sections for manufacture of demountable magnets that allow for highly reliable, re-makeable joints that exhibit excellent structural integrity, low electrical resistance, low ac losses, and high stability in high magnetic field and in pulsed applications. These include conventional lap and butt joints, as well as very high current plate-to-plate joints. Reliable sliding joints can be considered.

Innovative structural support methods and materials, and magnet cooling and quench protection methods suitable for operation in a fusion radiation environment that results in high overall current density magnets.

Novel, advanced sensors and instrumentation for monitoring magnet and helium parameters (e.g., pressure, temperature, voltage, mass flow, quench, etc.); of specific interest are fiber optic based devices and systems that allow for electromagnetic noise-immune interrogation of these parameters as well as positional information of the measured parameter within the coil winding pack. A specific use of fiber sensors is for rapid and redundant quench detection. Novel fiber optic sensors may also be used for precision measurement of distributed and local temperature or strain for diagnostic and scientific studies of conductor behavior and code calibration.

Radiation-resistant electrical insulators, e.g., wrap able inorganic insulators and low viscosity organic insulators that exhibit low gas generation under irradiation, less expensive resins and higher pot life; and insulation systems with high bond and higher strength and flexibility in shear.

Questions – contact: Barry Sullivan, barry.sullivan@science.doe.gov

d. Structural Materials and Coatings

Fusion materials and structures must function for a long time in a uniquely hostile environment that includes combinations of high temperatures, reactive chemicals, high stresses, and intense damaging radiation. The goal is to establish the feasibility of designing, constructing and operating a fusion power plant with materials and components that meet demanding objectives for safety, performance, and minimal environmental impact.

Grant applications are sought for:

Development of innovative methods for joining beryllium (~2 mm thick layer) to RAFM steels. The resulting bonds must be resistant to the effects of neutron irradiation, exhibit sufficient thermal fatigue resistance, and minimize or prevent the formation of brittle intermetallic phases that could result in coating debonding.

Development of fabrication techniques for typical component geometries envisioned for use in test blanket modules for operation in ITER using current generation RAFM steels. Such fabrication techniques could include but are not limited to appropriate welding, hot-isostatic pressing, hydroforming, and investment casting methods as well as effective post joining heat treatment techniques and procedures. Appropriate fabrication technologies must produce components within dimensional tolerances, while meeting minimum requirements on mechanical and physical properties.

Development of oxide dispersion strengthened (ODS) ferritic steels. Approaches of interest include the development of low cost production techniques, improved isotropy of mechanical properties, development of joining methods that maintain the properties of the ODS steel, and development of improved ODS steels with the capability of operating up to ~800˚C, while maintaining adequate fracture toughness at room temperature and above.

Development of functional coatings for the RAFM/Pb-Li blanket concept. Coatings are needed for functions that include (1) compatibility: minimizing dissolution of RAFM in Pb-Li at 700°C, (2) permeation: reducing tritium permeation (hydrogen for demonstration) by a factor of >100 and (3) electrically insulating: reducing the pressure drop due to the magneto-hydrodynamic (MHD) effect. Proposed approaches must: (1) account for compatibility with both the coated structural alloy and liquid metal coolant for long-time operation at 500-700˚C (2) address the potential application of candidate coatings on large-scale system components; and (3) demonstrate that the permeation and MHD coatings are functional during or after exposure to Pb-Li.

Priority will be given to innovative methods or experimental approaches that enhance the ability to obtain key mechanical or physical property data on miniaturized specimens, and to the micromechanics evaluation of deformation and fracture processes.

Questions – contact: Pete Pappano, peter.pappano@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Barry Sullivan, barry.sullivan@science.doe.gov

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23. FUSION SCIENCE AND TECHNOLOGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

The Fusion Energy Sciences program currently supports several fusion-related experiments with many common objectives. These include expanding the scientific understanding of plasma behavior and improving the performance of high temperature plasma for eventual energy production. The goals of this topic are to develop and demonstrate innovative techniques, instrumentation, and concepts for (a) measuring magnetized-plasma parameters, (b) for low-temperature and multi-phase plasmas, (c) for magnetized-plasma simulation, control, and data analysis, and (d) for overcoming deleterious plasma effects during discharges. It is also intended that concepts developed as part of the fusion research program will have application to industries in the private sector. Further information about research funded by the Office of Fusion Energy Sciences (FES) can be found in the FES website at http://science.energy.gov/fes/.

Grant applications are sought in the following subtopics:

a. Diagnostics

Diagnostics are key to advancing our ability to predict and control the behavior of fusion plasmas. Applications are sought for the development of advanced diagnostic techniques to enable new way of studying plasma behavior, or to measure plasma parameters not previously accessible, or at a level of detail greater than previously possible, or at a substantially reduced cost or complexity, and for the development needed in applying existing diagnostics to new, relatively unexplored, or unfamiliar plasma regimes or scenarios. Development of diagnostics meeting needs for advancing the science of boundary and pedestal physics, explosive instability (including ELMs and disruptions), and long-pulse magnetized plasmas are particularly welcome. Development leading to dramatic reduction in the cost of particle accelerators (e.g. MEMS-based accelerators) suitable for use as a diagnostic for magnetic fusion experiments are encouraged, as well as new detectors and associated technologies to work with these accelerators as a diagnostic system. Requests seeking funding for the routine application or operation of proven and matured diagnostic techniques at the major fusion facilities will not be considered under this subtopic. Such diagnostic applications are typically funded via separate solicitations as part of experimental facilities, based on their own research program priorities.

Questions – contact: Francis Thio, francis.thio@science.doe.gov

b. Components for Heating and Fueling of Fusion Plasmas

Grant applications are sought to develop components related to the generation, transmission, and launching of high power electromagnetic waves in the frequency ranges of Ion Cyclotron Resonance Heating (ICRH, 50 to 300 MHz), Lower Hybrid Heating (LHH, 2 to 10 GHz), and Electron Cyclotron Resonance (or Electron Bernstein Wave) Heating (ECRH / EBW, 28 to 300 GHz). These improved components are sought for the microwave heating systems of the fusion facilities in the United States and facilities under construction including ITER. Components of interest include power supplies, high power microwave sources or generators, fault protection devices, transmission line components, and antenna and launching systems. Specific examples of some of the components that are needed include tuning and matching systems, unidirectional couplers, circulators, mode convertors, windows, output couplers, loads, energy extraction systems from spent electron beams and particle accelerators, and diagnostics to evaluate the performance of these components. Of particular interest are components that can safely handle a range of frequencies and increased power levels.

For the ITER project, the United States will be supplying the transmission lines for both the ECRH (2 MW/line) system, at a frequency of 170 GHz, and for the ICRH system (6 MW/line), operating in the range of 40 – 60 MHz.. For this project, grant applications are needed for advanced components that are capable of improving the efficiency and power handling capability of the transmission lines, in order to reduce losses and protect the system from overheating, arcing, damage or failure during the required long pulse operation (~3000s). Examples of components needed for the ECRH transmission line include high power loads, low loss miter bends, polarizers, power samplers, windows, switches, and dielectric breaks. Examples of components needed for the ICRH transmission line include high power loads, tuning stubs, phase shifters, switches, arc localization methods, and in line dielectric breaks. For the ECRH and ICRH ITER transmission lines, improved techniques are needed for the mass production of components, in order to reduce cost. Lastly, advanced computer codes are needed to simulate the radiofrequency, microwave, thermal, and mechanical components of the transmission lines.

Questions – contact: Barry Sullivan, barry.sullivan@science.doe.gov

c. Simulation and Data Analysis Tools for Magnetically Confined Plasmas

The predictive simulation of magnetically confined fusion plasmas is important for the design and evaluation of plasma discharge feedback and control systems; the design, operation, and performance assessment of existing and proposed fusion experiments; the planning of experiments on existing devices; and the interpretation of the experimental data obtained from these experiments. Developing a predictive simulation capability for magnetically confined fusion plasmas is very challenging because of the enormous range of overlapping temporal and spatial scales; the multitude of strongly coupled physical processes governing the behavior of these plasmas; and the extreme anisotropies, high dimensionalities, complex geometries, and magnetic topologies characterizing most magnetic confinement configurations.

Although considerable progress has been made in recent years toward the understanding of these processes in isolation, there remains a critical need to integrate them in order to develop an experimentally validated integrated predictive simulation capability for magnetically confined plasmas. In addition, the increase in the fidelity and level of integration of fusion simulations enabled by advances in high performance computing hardware and associated progress in computational algorithms has been accompanied by orders of magnitude increases in the volume of generated data. In parallel, the volume of experimental data is also expected to increase considerably, as U.S. scientists have started collaborations on a new generation of overseas long-pulse superconducting fusion experiments. Accordingly, a critical need exists for developing data analysis tools addressing big data challenges associated with computational and experimental research in fusion energy science.

Grant applications are sought to develop simulation and data analysis tools for magnetic fusion energy science addressing some of the challenges described above. Areas of interest include: (1) verification and validation tools, including efficient methods for facilitating comparison of simulation results with experimental data; (2) methodologies for building highly configurable and modular scientific codes and flexible user-friendly interfaces; (3) tools for creating interfaces to legacy codes; and (4) remote collaboration tools that enhance the ability of geographically distributed groups of scientists to interact and collaborate in real-time.

The simulation and data analysis tools should be developed using modern software techniques, should be capable of exploiting the potential of current and next generation high performance computational systems, and should be based on high fidelity physics models. The applications submitted in response to this call should have a strong potential for commercialization and should not propose work that is normally funded by program funds. Although applications submitted to this topical area should primarily address the simulation and data analysis needs of magnetic fusion energy science, applications proposing the development of tools and methodologies which have a broader applicability, and hence increased commercialization potential, are encouraged.

Questions – contact: John Mandrekas, john.mandrekas@science.doe.gov

d. Components and Modeling Support for Validation Platforms for Fusion Science

Small-scale plasma research experiments in the FES program have the long-term performance measure of demonstrating enhanced fundamental understanding of magnetic confinement and improving the basis for future burning plasma experiments. This can be accomplished through investigations and validations of the linkage between prediction and measurement for scientific leverage in testing the theories and scaling the phenomena that are relevant to future burning plasma systems. This research includes investigations in a variety of concepts such as stellarators, spherical tori, and reversed field pinches. Key program issues include initiation and increase of plasma current; dissipation of plasma exhaust power; symmetric-torus confinement prediction; stability, continuity, and profile control of low-aspect-ratio symmetric tori; quasi-symmetric and three-dimensional shaping benefits to toroidal confinement performance; divertor design for three-dimensional magnetic confinement configurations, and the plasma-materials interface. Grant applications are sought for scientific and engineering developments, including computational modeling, in support of current experiments in these research activities, in particular for the small-scale concept exploration experiments. The proposed work should have a strong potential for commercialization. Overall, support of research that can best help deepen the scientific foundations of understanding and improve the tokamak concept is an important focus area for grant applications.

Questions – contact: Sam Barish, sam.barish@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Barry Sullivan, barry.sullivan@science.doe.gov

References:

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1. C.K. Phillips & J. R. Wilson. (2011). *Radio Frequency Power in Plasmas: Proceedings of the 19th Topical Conference*. AIP Conference Proceedings. Volume 1406, pp.1-2. Newport, Rhode Island. June 1-3, 2011. ISBN: 978-0-7354-0978-1. Available at http://scitation.aip.org/content/aip/proceeding/aipcp/1406

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24. HIGH ENERGY DENSITY PLASMAS AND INERTIAL FUSION ENERGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

High-energy-density laboratory plasma (HEDLP) physics is the study of ionized matter at extremely high density and temperature, specifically when matter is heated and compressed to a point that the stored energy in the matter reaches approximately 100 billion Joules per cubic meter (the energy density of a hydrogen molecule). This corresponds to a pressure of approximately 1 million atmospheres or 1 Mbar. Research in HEDLP forms the scientific foundation for developing scenarios that could facilitate the transition from laboratory inertial confinement fusion (ICF) to inertial fusion energy (IFE).

While substantial scientific and technical progress in inertial confinement fusion has been made during the past decade, many of the technologies required for an integrated inertial fusion energy system are still at an early stage of technological maturity. This relative immaturity ensures that commercially viable IFE remains a long-term (>15 years) objective. Research and development activities are sought which address specific technology needs (specified below), necessary to both assess and advance IFE. Given the long-term prospects for IFE, applications submitted under this topical area must also clearly describe their potential/plans for short-term (2-10 years) commercialization in other commercial industries such as telecommunications, biomedical, etc.

Grant applications are sought in the following subtopics:

a. Driver Technologies

Inertial fusion energy hinges on the ability to compress an ICF target in tens of nanoseconds and repeat this process tens of times per second. Thus, the development of technologies is needed to build a driver (e.g., lasers, heavy-ions, pulsed power) that can meet the IFE requirements for energy on target, efficiency, repetition rate, durability, and cost. Specific areas of interest include but are not limited to: wavelength and beam quality for lasers, brightness for lasers and heavy ions, and pulse shaping and power.

Questions – contact: Curt Bolton, curt.bolton@science.doe.gov

b. Ultrafast Diagnostics

The development of ultrafast diagnostics is needed to assess driver and plasma conditions on sub-picosecond time scales. This technology has the potential to enable the development and deployment of feedback systems capable of ensuring the necessary reliability required for commercially viable IFE. Specific areas of interest include but are not limited to the generation, detection, and control of nonlinear optical processes in plasmas.

Questions – contact: Curt Bolton, curt.bolton@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Curt Bolton, curt.bolton@science.doe.gov

References:
General

1. *Advancing the Science of High Energy Density Laboratory Plasmas*. Report of the High Energy Density Laboratory Plasmas Panel of the Fusion Energy Sciences Advisory Committee. January 2009. http://science.energy.gov/~/media/fes/fesac/pdf/2009/Fesac_hed_lp_report.pdf

25. LOW TEMPERATURE PLASMAS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

Low-temperature plasma science and engineering addresses research and development in partially ionized gases with electron temperatures typically below 10 eV. This is a field that accounts for an enormous range of practical applications, from light sources and lasers to surgery and making computer chips, among many others. The commercial and technical value of low temperature plasma (LTP) is well established where much of this benefit has resulted from empirical development. As the technology becomes more complex and addresses new fields, such as energy and biotechnology, empiricism rapidly becomes inadequate to advance the state of the art. Predictive capability and improved understanding of the plasma state becomes crucial to address many of the intellectually exciting scientific challenges of this field.

Building upon fundamental plasma science, further developments are sought in plasma sources, plasma surface interactions, and plasma control science that can enable new plasma technologies or marketable product and impact in other areas or disciplines leading to even greater societal benefit. The focus is on utilizing fundamental plasma science knowledge and turning it into new applications. Use of readily available LTPs involving very little plasma science in a direct application of another field will not be considered. All research proposals must have a strong commercialization potential. Grant applications are sought in the following subtopics:

a. Low-Temperature Plasma Science and Technology for Biology and Biomedicine

One of the current challenges identified in the areas of biological and medical applications of low-temperature plasmas is improving our current understanding and scientific knowledge in the area of plasma-biomatter interactions. Specific examples include but are not limited to: plasma-based bacterial inactivation, cancer cell modification, etc.

Questions – contact: Curt Bolton, curt.bolton@science.doe.gov

b. Low-Temperature Plasma Science and Engineering for Plasma Nanotechnology

Another current challenge has been identified in plasma assisted material synthesis for improving our current understanding and scientific knowledge in the area of plasma nanotechnology. Specific examples include but are not limited to: plasma-based nanotubes, submicron matters, etc.

Questions – contact: Curt Bolton, curt.bolton@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this topic including plasmas separation technology, plasma assisted combustion and fuel generation, and MHD power generation.

Questions – contact: Curt Bolton, curt.bolton@science.doe.gov

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General

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PROGRAM AREA OVERVIEW: OFFICE OF HIGH ENERGY PHYSICS

Through fundamental research, scientists have found that all observed matter is composed of apparently point-like particles, called leptons and quarks. These constituents of matter were created following the "big-bang" that originated our universe, and they are components of every object that exists today. We also understand a great deal about the four basic forces of nature: electromagnetism, the strong nuclear force, the weak nuclear force, and gravity. For example, in the past we have learned that the electromagnetic and weak forces are two components of a single force, called the electro-weak force. This unification of forces is analogous to the unification in the mid-nineteenth century of electric and magnetic forces into electromagnetism. History shows that, over a period of many years, the understanding of electromagnetism has led to many practical applications that form the technical basis of modern society.

The goal of the Department of Energy’s (DOE) Office of High Energy Physics (HEP) is to provide mankind with new insights into the fundamental nature of energy and matter and the forces that control them. This program is a major component of the Department's fundamental research mission. Such fundamental research provides the necessary foundation that enables the nation to advance its scientific knowledge and technological capabilities, to advance its industrial competitiveness, and possibly to discover new and innovative approaches to its energy future.

The DOE HEP program supports research in three discovery frontiers, namely, the energy frontier, the intensity frontier, and the cosmic frontier. Experimental research in HEP is largely performed by university and national laboratory scientists, usually using particle accelerators located at major laboratories in the U.S. and abroad. Under the HEP program, the Department operates the Fermi National Accelerator Laboratory (Fermilab) near Chicago, IL. The Department also has a significant role in the Large Hadron Collider (LHC) at the CERN laboratory in Switzerland. The Tevatron Collider at Fermilab was the world's highest energy accelerator for over a decade, until the startup of the LHC. The Fermilab complex also includes the Main Injector, which is used independently of the Tevatron to create high- energy particle beams for physics experiments, including the world’s most intense neutrino beam. The SLAC National Accelerator Laboratory and the Lawrence Berkeley National Laboratory are involved in the design of state-of-the-art accelerators and related facilities for use in high-energy physics, condensed matter research, and related fields. SLAC facilities include the 3 kilometer long Stanford Linear Accelerator capable of generating high energy, high intensity electron and positron beams. The first 2 kilometers of the linear accelerator is currently being used for the Facility for Advanced Accelerator Experimental Tests (FACET). While much progress has been made during the past five decades in our understanding of particle physics, future progress depends on a great degree of availability of new state-of-the-art technology for accelerators, colliders, and detectors operating at the high energy and/or high intensity frontiers.

Within HEP, the Advanced Technology subprogram supports the research and development required to extend relevant areas of technology in order to support the operations of highly specialized accelerators, colliding beam facilities, and detector facilities which are essential to the goals of the overall HEP program. As stewards of accelerator technology for the nation, HEP also supports development of new concepts and capabilities that further scientific and commercial needs beyond the discovery science mission. The DOE SBIR program provides a focused opportunity and mechanism for small businesses to contribute new ideas and new technologies to the pool of knowledge and technical capabilities required for continued progress in HEP research, and to turn these novel ideas and technologies into new business ventures.

For additional information regarding the Office of High Energy Physics priorities, click here.

26. ADVANCED CONCEPTS AND TECHNOLOGY FOR PARTICLE ACCELERATORS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. The strategic plan for HEP includes initiatives on the energy and intensity frontiers, relying on accelerators capable of delivering beams of the required energy and intensity. As high energy physics facilities get bigger and more costly, the DOE HEP program seeks to develop advanced technologies that can be used to reduce the overall machine size and cost, and also to develop new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

In many cases the technology sought is closely tied to a specific machine concept which sets the specifications (and tolerances) for the technology. Applicants are strongly encouraged to review the references provided. Applications to subtopics specifically associated with a machine concept that do not closely adhere to the specifications of the machine will be returned as non-responsive.
For subtopics that are not machine-specific, applicants are strongly advised to understand the state-of-the-art and to clearly describe in the application what quantitative advances in the technology will result.

Grant applications are sought only in the following subtopics:

a. Advanced Accelerator Concepts and Modeling

Beamline Components for Emittance Re-partitioning: Grant applications are sought to develop phase space manipulation and associated beamline components capable of repartitioning the beam emittances within the three degrees of freedom.

Beamline Components for Beam Current Profile Shaping: High transformer ratios (>>2) are essential for practical collinear wakefield accelerators. One promising approach is the use of the emittance exchange technique to shape the axial beam current profile of the drive beam, for example to generate a double-triangular current distribution. Grant applications are sought to design and demonstrate phase space manipulation techniques for tailoring the beam current profile to enhance the performance of beam-driven acceleration techniques.

Mitigation and Measurement of CSR in Bends: Degradation of high current beams caused by Coherent Synchrotron Radiation (CSR) in pulse compressors and beamline bends is an important concern for accelerators. The emitted rf wave or modes that are trapped inside the vacuum chamber could be diagnosed using either rf detection or witness beam techniques. Grant applications are sought to study CSR effects in bends, to develop mitigations using lattice or shielding techniques, and to demonstrate the effectiveness of the mitigation techniques at a beam facility.

Optical Stochastic Cooling: Grant applications are sought to design and develop a high-precision Optical Stochastic Cooling insert for an electron ring. The insert would consist of a pick-up undulator, a chicane with specific M56 properties, and a kicker undulator. The Optical Stochastic Cooling method described in reference [1] has the potential to cool electrons as well as heavier particles.

Supersonic Gas Jets with Programmable Density Profiles: Grant applications are sought to develop high density (range of 10^{19}-10^{20} /cc), high repetition rate (≥10 Hz) pulsed gas jets with precisely shaped density profiles. Efficient acceleration of mono-energetic proton beams can be achieved with a CO_2 gas laser focused on a pulsed supersonic gas jet with tailored longitudinal density profile. The main goal of a shaped density gas jet is to prevent the appearance of electrostatic fields at the rear surface of the target; these fields are responsible for energy broadening of the ion beam. The most effective way to reduce those fields is to introduce an exponential drop in density over a scale length of a few hundred microns. The density profile at the front of the gas jet should follow a linear increase in density over a distance of 100 to 150 microns. In order to accelerate protons to high energies, the gas jet peak density should be controlled from about the critical density of the laser driver used, which is 10^{19}/cc for CO_2 lasers to as much as ten times the critical density.

Plasma Targets with Programmable Density Profiles: Grant applications are sought to enable precisely shaped plasma target density profiles including hollow plasma channels for emittance control, and density tailoring for injection and guiding, in laser plasma accelerators. Approaches include the use of pulsed cluster gas jets, where high local density within clusters greatly enhances coupling of laser energy into both ions and electrons [1]. Together with the ballistic behavior of the clusters around flow obstacles, this can enable plasma shaping using low energy table top laser systems. Hydrogen clusters are important to enable use of the resulting plasma for high intensity laser targets, and high repetition rate (≥10 Hz) is needed. A well-characterized source that produces clustered gases of carefully controlled size, composition, and high mean density is important to the ability to create density tailoring. Other approaches to nearly hollow channels are also of interest.

Novel High Gradient Accelerating Techniques: Grant applications are sought to develop new or improved accelerator designs that can provide very high gradient (>200 MV/m for electrons or >15 MV/m for protons) acceleration of intense bunches of particles, or efficient acceleration of intense (>50 mA) low energy (of order <20 MeV) proton beams. For all proposed concepts, stageability, beam stability, manufacturability, and high-wall-plug-to-beam power efficiency must be considered.

Novel Accelerator Topologies: Grant applications are sought to demonstrate efficient low-loss proton acceleration in the energy range of 5-25 GeV using non-scaling, fixed-field alternating-gradient (ns-FFAG) accelerators, superconducting cyclotrons, or integrable optics accelerators. The HEP application of interest is for high-intensity proton drivers for neutron production. Applications beyond HEP include neutron sources for reactor materials testing, waste transmutation, energy production in sub-critical nuclear reactors, and lower-intensity applications such as medical proton therapy (250 MeV), and radioisotope production.

Advanced Concepts and Modeling for Mu2e [4]: Grant applications are sought for concepts for high efficiency slow extraction from storage rings with high intensity beams. Of primary interest are concepts for extraction systems capable of extracting proton beams of tens of kilowatts, with efficiencies in excess of 99%.

Novel beam optics for high-energy, high-intensity proton accelerators: Grant applications are sought for the development of new ideas in beam optics and lattice design for the High-Luminosity LHC (HL-LHC), for the proton improvement plan (PIP-II) at Fermilab and for other proposed proton facilities that will advance the energy frontier or the intensity frontier. The drive towards higher luminosity calls for flat proton beams with ultra-low emittance in one transverse plane; however, space charge tune shifts in the injector chain can become unacceptably large for present lattice designs. Fundamentally different approaches to lattice design may enable order-of-magnitude lower emittances, with corresponding increases in luminosity. For intensity frontier rings, one of the intensity-limiting effects is excitation of head-tail space charge modes, which are still not understood in necessary detail. Computational studies of such modes in realistic lattices are required to better understand the importance of such modes and to develop ways of suppressing them.

Advanced Concepts and Modeling for PIP-II: Grant applications are sought to develop new or improved accelerator designs and supporting modeling that can provide efficient acceleration of intense particle beams in either linacs or synchrotrons with beam losses of less than 1 W/m. Topics of interest include: (1) Linac configurations, either pulsed or CW, capable of delivering >1 MW beams at energies between 1-10 GeV; (2) Halo formation in pulsed or CW linacs; (3) Concepts for high intensity rapid cycling synchrotrons; (4) Space-charge mitigation techniques; and (5) New methods for multi-turn H– injection, including laser stripping techniques.

Multi-MW proton (or H-) source: Grant applications are sought for multi-MW proton (or H-) source to support intensity frontier programs based on neutrino, muon, kaon, and neutron/nuclei probes. Other possible applications include high-intensity proton drivers for waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy, and radioisotope production.

Questions – contact: John Boger, john.boger@science.doe.gov

b. Computational Tools and Simulation of Accelerator Systems

Improved Accelerator Modeling Simulation Codes: Grant applications are sought to develop new or improved computational tools for the design, study, or operation of charged-particle-beam optical systems, accelerator systems, or accelerator components. These tools should incorporate innovative user-friendly interfaces, with emphasis on graphical user interfaces and windows, and tools to translate between standard formats of accelerator lattice description. Grant applications also are sought for the conversion of existing codes for the incorporation of these interfaces (provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate).

Improved Integration of Accelerator Codes: Grant applications also are sought for user-friendly tools in software integration for different components including preprocessors and postprocessors of existing codes or for different application codes into a framework to enhance simulation of accelerator systems [1].

Accurate Modeling and Prediction of High Gradient Breakdown Physics: Grant applications also are sought to develop simulation tools for modeling high-gradient structures, in order to predict such experimental phenomena as the onset of breakdown, post breakdown phenomena, and the damage threshold. Specific areas of interest include, although not limited to, the modeling of: (1) Surface emission, (2) Material heating due to electron and ion bombardment, (3) Multipacting, and (4) Ionization of atomic and molecular species. Approaches that include an ability to import/export CAD descriptions, a friendly graphical user interface, and good data visualization are sought.

Grant applications are sought for development and deployment of codes and software modules that are important to HEP projects and for which current capabilities do not exist or are not sufficient. In the past decade HEP-driven accelerator modeling codes have become increasingly sophisticated. Particularly noteworthy is the fact that accelerator codes now combine multiple phenomena, such as single particle nonlinear optics, space-charge effects, beam-beam effects, and beam-material interactions. But there are some phenomena that are important to the HEP mission that are still missing from accelerator codes. Proposals are sought for codes and modules to self-consistently model the interaction of beams with plasmas, including beam-plasma interactions in gas-filled rf cavities, plasma production by incoming beams, and plasma and atomic physics processes. Proposals are also sought for developing codes capable of modeling collective effects in matter.

Questions – contact: John Boger, john.boger@science.doe.gov

c. Particle Beam Sources (Electron and Ion)

High Brightness Electron Sources: Grant applications are also sought to demonstrate technologies that support the production of high-peak current (> 5 kA), low-emittance (< 0.15 micrometer) electron bunches (> 100 pC). Novel emittance partitioning concepts are of particular interest, including developing high compression ratio (>20) bunch compressors based on coupled emittance exchangers that suppress effects from coherent synchrotron radiation.

Particle Beam Sources for PIP-II [1]/ High Intensity Proton Sources: Grant applications are sought for the design, and demonstration unit(s), of low emittance DC H– sources capable of operating at up to 15 mA with a long lifetime. Long lifetime means greater than one month, minimum, with concurrent high reliability in operations. Of particular interest are sources operating at ~30 keV.

Questions – contact: John Boger, john.boger@science.doe.gov

d. Novel Device and Instrumentation Development

Novel Device and Instrumentation Development for PIP-II [1]: Grant applications are sought for beam deflecting devices that can be used to remove or deflect proton or ion bunches for the purpose of forming variable bunch patterns in high intensity proton accelerators (see also “Deflecting Cavities” in next topic).

Specific areas of interest include:

Deflecting structures capable of removing individual bunches within a beam from a ~2 MeV CW source, and with a 162.5 MHz bunch structure; specifically with capabilities of providing arbitrary chopping patterns based on selective removal of bunches spaced at 6 nsec; and

Driver concepts, either amplifier or switch based, suitable for driving such deflectors with several 100 volts into impedances of 50 or 200 Ohms.

Fast Beam Kicker: Grant applications are sought for a fast beam kicker with 50 ns rise time and 150 kV total transverse kick.

Questions – contact: John Boger, john.boger@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact John Boger, john.boger@science.doe.gov

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Subtopic c

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27. RADIO FREQUENCY ACCELERATOR TECHNOLOGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Radio frequency (RF) technology is a key technology common to all high energy accelerators. RF sources with improved efficiency and accelerating structures with increased accelerating gradient are important for keeping the cost down for future machines. DOE-HEP seeks advances directly relevant to HEP applications, and also new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

In many cases the technology sought is closely tied to a specific machine concept which sets the specifications (and tolerances) for the technology. Applicants are strongly encouraged to review the references provided. Applications to subtopics specifically associated with a machine concept that do not closely adhere to the specifications of the machine will be returned as non-responsive.

For subtopics that are not machine-specific, applicants are strongly advised to understand the state-of-the-art and to clearly describe in the application what quantitative advances in the technology will result.

Grant applications are sought only in the following subtopics:

a. Radio Frequency Power Sources and Components

High Gradient Research & Development: Grant applications are sought for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >150 MV/m for electrons and >10 MV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and reducing costs.

Mitigation Techniques for Surface Breakdown and Multipactoring: Methods for reducing surface breakdown and multipactoring (such as spark-resistant materials or surface coatings, or special geometries) and for suppressing unwanted higher order modes also are of interest, as are studies of surface breakdown and its dependence on magnetic field. Grant applications should be applicable to devices operating at frequencies from 1 to 40 GHz. Laser-initiated rf breakdown is an important issue in high performance photoinjectors. Grant applications are sought to study the origin and mitigation of laser triggered rf breakdown at the photocathode.

Analysis and Mitigation of High Repetition Rate Effects in Dielectric Wakefield Accelerators: The interaction of dielectric materials with beam halo might become a significant limiting effect on the performance of dielectric wakefield devices, leading either to deflection of the beam by the static electric field generated, or to breakdown of the structure. Grant applications are sought which emphasize experimental, theoretical or computational studies of the expected charging rate and charge distribution in a thin walled dielectric device and the physics of conductivity and discharge phenomena in dielectric materials useful in accelerator applications.

Low-Temperature Bonding Techniques for Hard Copper and Hard Copper Alloys: Recent research on high-gradient normal conducting accelerator structures showed significant advantages of hard copper and hard copper alloys over annealed copper [1,2]. Hard copper and hard copper alloys (e.g. copper-silver) allow these structures to run stably at higher gradients than annealed copper. However, normal manufacturing techniques, which include brazing and or diffusion bonding, anneal the copper; in the case of copper alloys there are no established bonding techniques. Grant applications are sought that can address the development of manufacturing techniques that preserve the hardness of copper or its alloys while at the same time maintains high degree of surface integrity and cleanliness for high gradient operation. Plating, low temperature brazing, and welding are examples of possible technologies for bonding structure cells; however, we would also welcome other ideas and technologies.

Low Cost Radio Frequency Power Source for Accelerator Applications: A magnetron [3] represents a very economical microwave source with a cost of a few $/kW. The development of a low cost and highly-efficient RF source for particle acceleration to energies in the 100 GeV to multi-TeV range would have significant impact on the cost of proposed high energy physics accelerators. Such a source would also be useful for other accelerator applications. Under typical operating conditions, the magnetron is an oscillator rather than an amplifier and control of output power is a problem when used as a source for accelerators. The design of a magnetron can be modified to allow the control of its output power within a limited range, roughly ±10%, by the incorporation of a low-voltage control grid. In principle, this control can be achieved with effective timescales of a few milliseconds by means of adding a low-voltage grid to the standard magnetron design which will allow modulation of the electron current and hence the power. Grant applications are sought to design and simulate the performance of a magnetron with a control grid to optimize the geometry of the grid and cathode. On the basis of the optimized design, a prototype would be constructed to study the performance over a range of operating voltages and to evaluate the power, frequency, phase and amplitude characteristics.

Radio Frequency Power Sources and Components for PIP-II [4]: Grant applications are sought for the development of power sources for accelerating cavities operating with 1-5 mA of average beam current in linacs capable of accelerating protons and ions to several GeV. Frequencies of interest include 325 and 650 MHz. Both pulsed and continuous wave (CW) applications are of interest. Examples of systems of interest include, but are not limited to: klystrons, solid state, inductive output, and phase locking magnetron devices; their associated power supplies; and associated low level radio frequency (LLRF) control systems.

Pulsed applications of interest include sources capable of delivering high peak power (multi-MW) with pulse lengths in the range 6-30 msec at 10 Hz. Grant applications are sought for the following specific rf sources and components:

L-Band Medium Power Tube – 1.3 GHz, 350 kW, 1.6 millisecond pulses at 5 Hz or 10 Hz.

Solid State S-band Klystron Drivers – Peak output power +60dBm at 0.2% duty, 37 dB gain, 5 microsec, 240 Hz, pulse to pulse added noise jitter (10Hz to 2MHz BW) less than 30 fs rms. The amplifier should be designed for installation in a 19 inch rack mount chassis and weigh less than 30 pounds.

S-band Pulse Compressor – Power compression ratio ranging from 4 to 8, efficiency >70%, return loss >25 dB, input power >50MW peak, 120 Hz repetition rate, radiation emissions < 10 mrem/hr.[5]

S-Band Power Circulator – 65MW peak, 4 microsec pulse length, 120 Hz repetition rate, return loss >25 dB, insertion loss < 0.2dB.

S-Band Dry Vacuum Loads – 30 MW peak power, 5 kW average power.

X-band Klystron Drivers – 2 kW, 5 µs, 360 Hz, 100 MHz bandwidth, 50 dB gain, low noise (<0.1 degree).

X-band Circulator – 50MW peak, 2 microsec pulse length, 120 Hz repetition rate, return loss >25 dB, insertion loss < 0.2dB.

X-band Vacuum Loads – Two types are sought: 50 MW peak/5 kW average, and 5 MW peak/25 kW average.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

b. Pulsed Power Systems

Thyratron Replacement for SLAC Modulators – Grant applications are sought for a replacement for existing thyratron switch tubes that are used in line type modulators. The replacement must meet SLAC specification PS-235-380-00-R4 with the addition of an increase in peak reverse voltage hold of (10kV) and a MTBF of 10,000 hours with a stable recovery process. A desirable feature would be a design that allows for replacement or repair of the cathode.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

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28. LASER TECHNOLOGY R&D FOR ACCELERATORS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Lasers are used or proposed for use in many areas of accelerator applications: as drivers for novel accelerator concepts for future colliders, in the generation, manipulation, and x-ray seeding of electron beams, in the generation of electromagnetic radiation ranging from THz to gamma rays, and in the generation of neutron, proton, and light ion beams. In many cases ultrafast lasers with pulse lengths well below a picosecond are required, with excellent stability, reliability, and beam quality. With applications demanding ever higher fluxes of particles and radiation, the driving laser technology must also increase in repetition rate—and hence average power—to meet the demand. Please note that proposals submitted in this topic should clearly articulate the relevance of the proposed R&D to HEP's mission.

Grant applications are sought to develop lasers and laser technologies for accelerator applications only in the following specific areas:

a. Ultrafast Infrared Laser Systems at High Peak and Average Power

This area is aimed at developing technologies for ultrafast lasers capable of high average power (kilowatt-class) operating at the high electrical-to-optical efficiency (>20%) needed for advanced accelerator applications. Accelerator applications call for lasers with one of four basic specifications:

	Type I	**Type II**	**Type III**	**Type IV**
Wavelength (micron)	1.5-2.0	0.8-2.0	2.0-5.0	2.0-10.0
Pulse Energy	3 microJ	3 J	0.03–1 J	300 J
Pulse Length	300 fs	30–100 fs	50 fs	100–500 fs
Repetition Rate	1–1300 MHz	1 kHz	1 MHz	100 Hz
Average Power	Up to 3 kW	3 kW	3 kW and up	30 kW
Energy Stability	<1 %	<0.1%	<1%	<1%
Beam Quality	$M^2<1.1$	Strehl>0.95	$M^2<1.1$	$M^2<1.1$
Wall-plug Efficiency	>30%	>20%	>20%	>20%
Pre-Pulse Contrast	N/A	$>10^{-9}$	N/A	$>10^{-9}$
CEP-capable	Required	N/A	Required	N/A
Optical Phase Noise	$<5^{o}$	N/A	$<5^{o}$	N/A
Wavelength Tunability Range	0.1%	0.1%	10%	0.1%

To develop lasers meeting these challenging requirements, we seek applications in the five fundamental technology areas which follow.

Improved Efficiency Laser Diodes for Pumping at Long Wavelength – While pump diodes at 980 nm have achieved efficiencies beyond 50% in commercial products, pump laser diodes for longer wavelength pumping of Erbium and Thulium fibers remain less efficient. Gains of 10% or more in electrical-to-optical power efficiency are needed to enable longer wavelength fiber lasers to achieve high efficiency.

Ceramic-Based Optical Materials – To achieve high average power and high peak power will require new gain materials with superior damage threshold, dopant density, optical bandwidth, and thermal properties. Sintered laser gain materials for ultrafast lasers offer promise of achieving many of these characteristics. Broad bandwidth (>10%) and scalability to high peak power (>10 TW), high average power (>kW) operation is essential. In addition, the development of techniques for producing precisely controlled spatial gain profiles is strongly encouraged.

Mode-Locked Seed Laser for High Repetition Rate Applications – Seeding Type I laser systems for accelerators and photocathode electron sources both require very high repetition rate laser oscillators producing modelocked pulses with exceptional timing, pointing, and energy stability. Applications are sought for a modelocked Erbium fiber laser producing 1 ps pulses at 1.3 GHz with 0.1 microJ per pulse. Technology must support synchronization to an external reference with < 10 fs rms timing jitter, and must be upgradeable to incorporate carrier-envelope phase locking.

Cost Reduction of Ultrafast Fiber Laser Components – Another route to achieving high peak and average power is to coherently combine the output of many (e.g. thousands of) ultrafast fiber lasers. In this case, power efficiency, beam quality, compactness, reliability, stability, and low cost of the individual lasers are each essential. Note that components and subsystems must be developed for propagating and amplifying high-quality (M^2<1.2) ultrafast (<100 fs) laser pulses. Proposals that develop integrated subsystems will be given highest priority, although proposals for individual components that offer revolutionary gains in any of the performance characteristics above will also be welcomed.

Solid State Seed Lasers for Ultrafast CO_2 Laser Systems – Ultrafast CO_2 laser systems operating at high peak and average power could drive compact proton and ion sources for a variety of applications. Developing a solid-state ultrafast seed laser for such systems is a key step towards achieving robust, economic operation. Proposals that develop all-solid-state seed laser systems capable of directly seeding high-pressure CO_2 laser amplifiers with <500 fs pulses of 100 nJ/pulse are sought. Technology must be scalable to 100 Hz repetition rate.

Questions – contact: Eric Colby, eric.colby@science.doe.gov

b. Optical Coatings for Ultrafast Optics

The cost and reliability of ultrafast laser systems depend in part on the optical robustness of coated optics such as mirrors and windows. R&D proposals are sought that will lead to significant advances in low loss, low scatter, ultra-high damage threshold broad-bandwidth coatings that can sustain fluences exceeding >2 J/cm^2 for 100 fs pulses. Coatings must also be stable at incident average powers exceeding 100 W, and provide high quality transmission or reflection properties over >10% bandwidth under both vacuum and in-air use.

Questions – contact: Eric Colby, eric.colby@science.doe.gov

c. Robust Nonlinear Optical Materials

Nonlinear optical materials for frequency conversion are key to producing a wide array of laboratory-scale sources of radiation. Materials supporting conversion of laser power to frequencies in the terahertz to EUV range (λ=300–0.1 micron) at high conversion efficiency, high damage threshold, and at high average power (>100 W incident power, cw) are sought.

Questions – contact: Eric Colby, eric.colby@science.doe.gov

d. Drive Lasers and for Photocathode Electron Sources

Applications are sought for developing turn-key commercial laser systems and subsystems for driving high-brightness photocathodes.

a) A self-contained turn-key laser system (including environmental enclosure and controls) producing 50 Watts of 520nm light in 1 psec pulses at 1.3 GHz with no more than 100 fsec rms timing jitter with respect to an external microwave timing reference is sought. The resultant beam must be shaped temporally and spatially, as well as have the ability for producing varying pulse trains.

b) Practical and highly efficient (>90%) methods are sought for advanced laser shaping. The technique must allow a wide range of transverse shapes (elliptical to flattop) and spot sizes (0.3-3 mm) to be projected onto a photocathode to mitigate non-linear space charge effects and concomitant emittance degradation. The shaping system must preserve the laser beam quality and be usable with high powers (10's of Watts of average laser power).

Questions – contact: Eric Colby, eric.colby@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Eric Colby, eric.colby@science.doe.gov

References:

General

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29. SUPERCONDUCTOR TECHNOLOGIES FOR PARTICLE ACCELERATORS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in high-field superconductor, superconducting magnet, and superconducting RF technologies. This topic addresses only those superconducting magnet development technologies that support accelerators, storage rings, and charged particle beam transport systems, and only those superconducting wire technologies that support long strand lengths suitable for winding magnets without splices.

Grant applications are sought only in the following subtopics:

a. High-Field Superconducting Wire Technologies for Magnets

Grant applications are sought to develop new or improved superconducting wire for high field magnets that operate at 16 Tesla (T) field and higher. Proposals should address production scale (> 3 km continuous lengths) wire technologies at 16 to 25 T and demonstration scale (>1 km lengths) wire technologies at 25 to 50 T. Current densities should be at least 400 amperes per square millimeter of strand cross-section (often called the engineering current density) at the target field of operation and 4.2 K temperature. Tooling and handling requirements restrict wire cross-sectional area to the range 0.4 to 2.0 square millimeters, with transverse dimension not less than 0.25 mm. Vacuum requirements in accelerators and storage rings favor operating temperatures below 20 K, so high-temperature superconducting wire technologies will be evaluated only in this temperature range. Primary materials of interest are Nb_3Sn, $Bi_2Sr_2CaCu_2O_8$ (Bi-2212), and $(RE)Ba_2Cu_3O_7$ (ReBCO); other materials may be considered if high field performance, length, and cost equivalent to these primary materials can be demonstrated. All grant applications must result in wire technology that will be acceptable for accelerator magnets, including not only the operating conditions mentioned above, but also delivery of a sufficient amount of material (1 km minimum continuous length) for winding and testing small magnets.

New or improved wire technologies must demonstrate at least one of the following criteria ***in comparison to present art***: (1) property improvement, such as higher current density or higher operating field; (2) improved tolerance to property degradation as a function of applied strain; (3) reduced transverse dimensions of the superconducting filaments (sometimes called the effective filament diameter), in particular to less than 30 micrometers at 1 mm wire diameter, with minimal concomitant reduction of the thermal conductivity of the stabilizer or strand critical current density; (4) innovative geometry for ReBCO materials that leads to lower magnet inductance (cables) and lower losses under changing transverse magnetic fields; (5) correction of specific processing flaws (*not* general improvements in processing), to achieve properties in wires of more than 1 km length that are presently restricted to wire lengths of 100 m or less; (6) significant cost reduction for equal performance in all regards, especially current density and length.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

b. Superconducting Magnet Technology

Grant applications are sought to develop: (1) very high field (>20 T) dipoles; (2) designs and prototypes for HTS/LTS hybrid solenoid systems capable of achieving 30 to 40T axial fields and warm bores with a diameter ≥2 cm, which are of particular interest for final cooling of a muon beam prior to acceleration and injection into a collider storage ring, but could also have broader application; (3) alternative designs – to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets – that may be more compatible with the more fragile Nb_3Sn and HTS/high-field superconductors (including open midplane magnets that may be needed in a Muon Collider design); (4) fast cycling HTS magnets capable of operation at or above 4T/s; (5) reduction in magnetization induced harmonics in HTS magnets; (6) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (7) improved current lead and current distribution systems, based on high-temperature superconductors, for application to superconducting accelerator magnets – requirements include an operating current level of 5 kA or greater, stability, low heat leak, and good quench performance; (8) improved industrial fabrication methods for magnets, such as welding and forming, that could lead to lower costs; (9) improved cryostat and cryogenic techniques; (10) quench protection in HTS magnets and HTS/LTS hybrid magnets.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

c. Superconducting RF Materials & Cavities

Materials and Fabrication Technologies for SRF Cavities – Material properties, surface features, processing procedures, and cavity geometry can have significant impact on the performance of superconducting radio-frequency (SRF) accelerator cavities. Grant applications are sought to develop (1) new raw materials streams, such as those utilizing large-grain Nb ingot slices; (2) new or improved SRF cavity fabrication techniques, such as seamless and weld-free approaches; (3) SRF cavity fabrication techniques that reduce use of expensive metals such as niobium while achieving equivalent performance as bulk niobium cavities; (4) new or improved bulk processing technologies, such as mechanical or plasma polishing; (5) new or improved final surface preparation and protection technologies; and (6) new cavity ideas aimed at breakthroughs in understanding and performance of SRF cavities.

SRF Cavities – Grant applications are sought for the development of superconducting radiofrequency cavities for acceleration of proton and ion beams, with relativistic betas ranging from 0.1 to 1.0. Frequencies of current interest include 325, 650, and 1300 MHz. Continuous wave (CW) cavities are of the greater interest, although pulsed cavities could also be supported. Accelerating gradients above 15 MV/m, at Q_0 in excess of 2×10^{10} (CW), and above 25 MV/m at Q_0 in excess of 1×10^{10} (pulsed) are desirable. Topics of interest include: (1) cavity designs; (2) cavity fabrication alternatives to electron beam welding, including for example hydroforming and automatic TIG or laser welding of cavity end groups; (3) other cavity and cryomodule cost reduction methods; (4) cw power couplers at >50kW; (5) fast tuners for microphonics control; (6) higher order mode suppressors, including extraction of HOM power via the main power coupler and with photonic band gap cavities; (7) ecologically friendly or alternative cavity surface processing methods; (8) alternatives to high pressure rinsing that would allow in-situ cleaning of cavities to control field emission; (9) high resolution tomographic x-rays of electron beam welds in cavities; (10) specifically for muon acceleration, design of a cost-effective 325 MHz cavity capable of 20 MV/m with $Q_0 > 10^9$ that is compatible with expansion to a two or three cell cavity system; possible approaches could include: forming a cavity from a bonded sheet of thin Nb on Cu, robust sputter coating of Nb on a Cu cavity, and electroforming Cu on a thin Nb cavity shell

Questions – contact: Ken Marken, ken.marken@science.doe.gov

d. Cryogenic and Refrigeration Technology Systems

Many new accelerators are based on the cold (superconducting) technology requiring large cryogenic systems. Grant applications are sought for research and development leading to the design and fabrication of improved cryomodules for superconducting cavity strings. Each cryomodule typically contains four to eight cavities in helium vessels and includes couplers, tuners, quadrupoles, 2K helium distribution system, and instrumentation to measure temperatures and pressures in the cryomodule during cool down and operation. Improvements in cryomodule components, cryomodule design and fabrication techniques which result in lower costs, improved control of cavity alignment, better understanding of cavity temperatures, and lower heat leaks are of particular interest. Other areas of interest include optimized methods for current leads for magnet operation at 2K where the helium pressures are sub atmospheric.

Grant applications also are sought to increase the technical refrigeration efficiency – from 20% Carnot to 30% Carnot – for large systems (e.g. 10 kW at 2K), while maintaining higher efficiency over a capacity turndown of up to 50%. This might be done, for example, by reducing the number of compression stages or by improving the efficiency of stages. Grant applications also are sought to develop improved and highly efficient liquid helium distribution systems.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

e. Ancillary Technologies for Superconductors

Grant applications also are sought to develop innovative cable designs and wire processing technologies. Approaches of interest include methods to use stranded conductors with high aspect ratio to make efficient magnet cables, methods to adapt tape geometries to particle accelerator applications, and technologies to increase wire piece length and billet mass.

Grant applications also are sought for innovative electrical insulating materials with reduced thickness to increase block current density in a coil while maintaining or increasing dielectric breakdown strength. Insulating systems must be compatible with the targeted superconductor and magnet processing cycle, (e.g. high temperature reactions in the 750-900 ºC range in the case of Nb_3Sn or BSCCO), be capable of supporting high mechanical loads at both room and cryogenic temperatures, have a high coefficient of thermal conductivity, be resistant to radiation damage, and exhibit low creep and low out-gassing rates when irradiated.

Grant applications also are sought for high-performance epoxies exhibiting the following characteristics: low viscosity regime for full impregnation of complex structures, reasonable pot-life to allow impregnation of large structures, high adhesion strength at cryogenic temperatures, excellent mechanical properties, including tensile, compression, and shear strength at cryogenic temperatures, and excellent radiation tolerance.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Ken Marken, ken.marken@science.doe.gov

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2. *The 2012 Applied Superconductivity Conference*. Portland, Oregon. October 7- 12. IEEE Transactions on Applied Superconductivity. Vol. 23, No. 3. ISSN: 1051-8223. Available at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77&year=2013

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2. *The 2012 Applied Superconductivity Conference*. Portland, Oregon. October 7- 12. IEEE Transactions on Applied Superconductivity. Vol. 23, No. 3. ISSN: 1051-8223. Available at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77&year=2013

30. HIGH-SPEED ELECTRONIC INSTRUMENTATION FOR DATA ACQUISITION AND PROCESSING

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE supports the development of advanced electronics and systems for the recording, processing, storage, distribution, and analysis of experimental data that is essential to experiments and particle accelerators used for High Energy Physics (HEP) research. Areas of present interest include signal processing, event triggering, data acquisition, high speed logic arrays, and fiber optic links useful to HEP experiments and particle accelerators. Grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities.

Although particle physics detector and data processing instrumentation typically are developed in large collaborative efforts involving national laboratories, there are efforts where small businesses can make innovative and creative contributions. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly. Areas of possible improvement include radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc.

Grant applications are sought in the following subtopics:

a. Special Purpose Chips and Devices for Large Particle Detectors

Grant applications are sought to develop special purpose chips and devices for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, low-overhead calibration, stability, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, analog waveform sampling, power conversion, picosecond-resolution time-to-digital converters, controllers, communications interface devices, and novel power distribution systems.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

b. Circuits and Systems for Processing Data from Particle Detectors

Grant applications are sought to develop circuits and systems for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, pixilated imaging sensors, particle calorimeters, large-area photodetector arrays, cryogenic detectors, and Cerenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters, time-to-amplitude converters, and local time, charge, and signal shape extraction. Compatibility with one of the widely used or evolving module interconnection standards is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

c. Systems for Data Analysis and Transmission

Grant applications are sought to develop advanced high-speed logic arrays and microprocessor systems for fast event identification, event trigger generation, low front-end data reduction, and data processing with very high throughput capability. Such systems should be compatible with or implemented in one of the widely used or evolving module interconnection standards. Grant applications also are sought for the innovative use of radiation tolerant ultrafast fiber optic links, electro-optic modulators, and/or commodity high-bandwidth networks for high-rate transmission of collected data between particle detectors and data recording or control systems. Approaches of interest should demonstrate technologies that feature one or more of the following characteristics: low bit-error rate, radiation tolerance, low failure rate, low power consumption, high packing density, and the ability to handle a large number of channels at very high rates.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

d. Enhancements to Standard Interconnection Systems

Grant applications are sought to develop (1) new modules that will provide capabilities not previously available; (2) technology to substantially enhance the performance of existing types of modules; (3) technology to reduce cost and increase the density of interconnection of sensors to readout electronics; and (4) components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems in HEP applications. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, CMOS monolithic active pixel sensors (MAPS) or vertically integrated (3D) electronics, communication modules and systems, wireless readout systems, and disk-drive interface modules.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

e. Special CMOS Sensors

Silicon particle tracking detectors for high energy physics are currently based on hybrid technology, with separately fabricated diode strip or pixel sensors and CMOS readout integrated circuits. As larger area detectors are required for tracking and also for new applications such as high granularity calorimetry, lower manufacturing cost is needed. Monolithic Active Pixel Sensors (MAPS) in CMOS have the potential for low cost, of order $0.1M or less per square meter of instrumented area. However, for use in high energy physics, detectors must withstand both ionizing and displacement damage radiation, and they must have fast signal collection and fast readout. Radiation tolerance in the range 10 to 1000 Mrad and 1E14 to 1E16 neutron equivalent fluence is of interest. Charge collection time of 20ns or less is of interest. Displacement damage tolerance and fast collection go hand-in-hand with high resistivity silicon that can be depleted of charged carriers with an applied bias voltage. Fabrication of MAPS sensors that offer these options in addition to ionizing radiation tolerance is of interest. Sustained (not burst) frame rate of 1MHz or higher for very low occupancy patterns (0.1%) is of interest.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

f. Large-area Silicon-based Sensors for Precise Tracking and Calorimetry

Next generation collider experiments will require finely segmented silicon-based tracking and calorimetry detectors which may cover 100's of square meters. These are typically based on wafer-scale high resistivity silicon diode arrays with 100-300 micron thick fully depleted active regions. Arrays based on tiled CMOS sensors and thinner active regions are also candidates. Grant applications are sought for the development of silicon diode-based sensors utilizing lower cost per unit area fabrication technologies. These may include sensors based on larger (8") wafer diameter, simplified processing, or tiling or stitching technologies. Desired properties include radiation hardness, thinning to the hundred micron-level, ten micron-level resolution capability for tracking detectors, and low cost in large volumes.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

g. Advanced 3D Interconnect Technologies

The demands on silicon particle tracking detectors in terms of pixel size, mass budget, data rate and front-end processing are becoming more demanding. Grants applications are sought for the development of new technologies for reducing cost and increasing the density of interconnection of pixelated sensors to readout electronics by enhancing or replacing solder bump-based technologies. The development of 3D vertically tiered silicon offers the potential to fabricate particle tracking detectors that could meet the requirements of next generation particle physics experiments. Cost-effective development of very thin front-end integrated circuits (< 35 microns) that can handle hit rates of 1GHz/cm2 , provide first pass processing of the registered hits and can be directly bonded to high-resistivity silicon sensors without the use of a bump-bond process is of great interest.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

h. Radiation-hard High Bandwidth Cables

As particle physics colliders increase their luminosity, the inner elements of detectors must both handle ever greater data rates and withstand every higher radiation doses. While high data rate optical solutions are often used at some point, they can have serious problems with high radiation. We therefore seek electrical transmission solutions for this specific area. We are interested in cables and electrical protocols that can support 2-4 Gbps transmission over distances of 2 to 6 meters with minimal mass and 10 Gbps over 4 to 7 meters with slightly higher mass. Bandwidth numbers refer to payload data, achieved with whatever DC balance, pre-emphasis, etc. protocols may be needed. Commercially available cables in these categories typically fail to meet other critical particle physics requirements. We require radiation hardness to 1Grad ionizing dose and 2E16/cm^2 neutrons equivalent damage. The cable should preserve mechanical integrity and electrical transmission characteristics after these radiation doses. Typical low loss dielectric materials tend to fail this requirement. We require very low mass, and the possibility to stack many individual multi-Gbps links into a small cross section cable. The mass requirement can be stated as equivalent to a single AWG30 copper wire per 2-4 Gbps link, and even less mass for the shortest (2m) distance, including any needed shields. The 10 Gbps links may be two or three times more massive. It is not actual weight that matters but opaqueness to radiation or "radiation length", as well as low activation from exposure to hadrons (so materials like silver, which readily activates, are excluded). Solutions of interest can involve copper-clad aluminum conductors, multi-stranded core conductors, aluminum shields, printed flexible cables, miniature coax or twinax solutions with radiation hard dielectrics, twisted pairs with minimal or no shielding, etc.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

i. Power Delivery Systems

Large collider experiments require low mass delivery of power to internal detector systems. Grant applications are sought for low mass, high efficiency powering systems such as DC-DC converters, serial powering, or alternative free-field power delivery systems. The devices must operate in a large magnetic field, and should be radiation hard.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

j. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this Topic

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

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31. HIGH ENERGY PHYSICS DETECTORS AND INSTRUMENTATION

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE supports research and development in a wide range of technologies essential to experiments in High Energy Physics (HEP) and to the accelerators at DOE high energy accelerator laboratories. The development of advanced technologies for particle detection and identification for use in HEP experiments or particle accelerators is desired. Broadly, the areas of interest are improvements in the sensitivity, robustness, and cost effectiveness of particle detectors. Principal areas of interest include particle detectors based on new techniques and technological developments, or detectors that can be used in novel ways as a consequence of associated technological developments in electronics (e.g., sensitivity or bandwidth). Also of interest are novel experimental systems that use new detectors, or use old ones in new ways, with significant improvement in performance, to extend basic HEP experimental research capabilities or result in less costly and less complex apparatus. Devices which exhibit insensitivity to very high radiation levels have recently become extremely important. Grant applications must clearly and specifically indicate their particular relevance to HEP programmatic activities.

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly. Areas of possible improvement include radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc.

Grant applications are sought in the following subtopics:

a. Particle Detection and Identification Devices

Grant applications are sought for novel ideas in the areas of charged and neutral particle detection and identification that could lead to improvements in the sensitivity, robustness, or cost effectiveness of particle detectors. These include ideas to advance the utility of detectors for the Energy Frontier such as at an upgraded or future collider; at the Intensity Frontier such as at a future long baseline neutrino experiment; and at the Cosmic Frontier such as a new Dark Matter detector. Examples include, but are not limited to, semiconductor particle detectors (silicon, CVD diamond, or other semiconductors), light-emitting particle detectors (scintillating materials including fibers, liquids, and crystals or Cherenkov radiators), low radioactivity detectors and associated components, large-area systems used for particle identification and multiple vertex separation, and gas or liquid-filled chambers (used for particle tracking, in calorimeters, and in Cherenkov or transition radiation detectors).

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

b. Photon Detectors

The detection of photons is fundamental for many detector applications. Applications include the following: 1) High quantum efficiency visible light photon detectors. 2) Development of lower cost photo-detection technology and production methods scalable to large detectors. 3) Photo-sensors for extreme environments including cryogenic temperatures, corrosive conditions, high and low pressures, electric and magnetic fields, and radiation relevant for future HEP applications. 4) Large-area photo-sensors with significantly improved space resolution and time resolution. 5) Photo-sensors with improved sensitivity in new regions of wavelength such as UV including improvements in windows and coatings. 6) New sensors for light detection. 7) Vacuum technology-based photo detection techniques. 8) Solid state technology-based photo detection techniques.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

c. Ultra-low Background Detectors and Materials

Experiments searching for extremely rare events such as nuclear recoils from WIMP dark matter particles or neutrinoless double beta decays require that the detector elements and the surrounding support materials exhibit extremely low levels of radioactivity. The presence of even trace amounts of radioactivity in or near a detector induces unwanted effects. (For example, the titanium cryostat of the LUX Dark Matter experiment has a measured radioactivity of ~6 mBq/kg due to the 238U sub-chain, and < 0.2 mBq due to the 226Ra sub-chain.) These elements could include: 1) Ultra-low-background neutron and alpha-particle detectors. 2) Development of ultra-radio-pure materials for use in detectors. 3) Manufacturing methods and characterization of ultra-low- background materials.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

d. Isotopically Separated Noble Gases

Neutrinoless double beta decay experiments using xenon need xenon enriched in the double beta decay isotope xenon-136 (136Xe), whereas xenon two neutrino double beta decays are potential backgrounds in xenon-based dark matter experiments. Argon-based dark matter experiments need to reduce contamination from radioactive 39Ar in 40Ar to reduce backgrounds. Economical sources of xenon enriched in 136Xe, and sources of argon depleted in 39Ar are needed for these experiments.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

e. Radiation Hard Devices

Many experiments must locate detectors within extreme radiation areas, e.g., at high luminosity LHC, or at a Muon Collider with muon beam decay background. For these applications radiation hardened devices are required. Applications include the following: 1) Radiation hardened/resistant optical links. 2) Radiation hardened/resistant power supplies or voltage converters, e.g. point of load converters. 3) Development of ultra-radiation hard material for use as detector elements. 4) Other radiation sensors for extreme environments.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

f. Cryogenic

Many detectors utilize cryogenic conditions and require cryogenic systems and devices which operate within a cryogenic environment. Applications include the following: 1) Development of the use, production and purification of cryogenic noble gases. 2) Cryogenic Liquid and Gas Particle Detectors. 3) Cryogenic Solid State Detectors.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

g. Mechanical and Materials

HEP experiments frequently require high performance detector support that will not compromise the precision of the detectors. Therefore, grant applications are sought for components used to support or integrate detectors into HEP experiments. The support components must be well matched to the detectors. For many experiments the presence of excess material is detrimental. These applications typically require low-mass and extremely rigid materials. Applications include the following: 1) Development of low mass detector support materials. 2) Novel low-mass materials with high thermal conductivity and stiffness. 3) Very high thermal conductivity, radiation tolerant adhesives. 4) Conventional detectors with substantially improved performance through the use of novel material science developments. 5) Improvements to manufacturing processes for radiation sensors and photo-sensors relevant for high energy physics. 6) 3D printing technology for rapid prototyping of detector components. The improvements should yield better performance, cost, faster production methods, or entirely new methods that make more efficient use of equipment.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

h. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Helmut Marsiske, helmut.marsiske@science.doe.gov

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PROGRAM AREA OVERVIEW – OFFICE OF NUCLEAR ENERGY

Continued use of nuclear power is an important part of the Department's strategy to provide for the Nation's energy security, as well as to be responsible stewards of the environment. Nuclear energy currently provides approximately 20 percent of the U.S. electricity generation and will continue to provide a significant portion of U.S. electrical energy production for many years to come. Also, nuclear power in the U.S. makes a significant contribution to lowering the emission of gases associated with global climate change and air pollution.

The primary mission of the Office of Nuclear Energy (NE) is to advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs by resolving technical, cost, safety, nonproliferation, and security barriers through research, development, and demonstration as appropriate [1].

For additional information regarding the Office of Nuclear Energy priorities see, http://nuclear.energy.gov/

32. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

New methods and technologies are needed to address key challenges affecting the future deployment of nuclear energy and to preserve U.S. leadership in nuclear science and engineering, while reducing the risk of nuclear proliferation. This topic addresses several key areas that support the development of crosscutting and specific reactor and fuel cycle technologies.

Grant applications are sought in the following subtopics.

a. Advanced Sensors and Instrumentation (Crosscutting Research)

The Advanced Sensors and Instrumentation program seeks applications for digital technology qualification demonstration for embedded digital devices. An embedded digital device is an electronic sub-component of a plant component (e.g. instrument or circuit breaker) which uses software or software-developed logic for some aspect of its operation. The qualification method will demonstrate a cost-effective means of ensuring that the device is not subject to software common cause failure. The selected digital equipment shall be for multiple reactors or fuel cycle applications, i.e. crosscutting, include a nuclear industry partner, and the research products shall address the following technical challenges:

- Proof of acceptable software operational reliability;
- Comprehensive non-destructive testability;

- U.S. NRC regulatory requirements;
- Ability to detect defects introduced through the entire supply chain;
- Ability to qualify commercial-grade devices dedicated for safety-related usage ; and
- Cost-effective and broadly applicable to multiple small plant components.

Grant applications that address the following areas are NOT of interest and will be declined: nuclear power plant security, homeland defense or security, or reactor building/containment enhancements; radiation health physics dosimeters (e.g., neutron or gamma detectors), and radiation/contamination monitoring devices; U. S. Nuclear Regulatory Commission probabilistic risk assessments or reactor safety experiments, testing, licensing, and site permit issues.

Questions – contact: Suibel Schuppner, Suibel.Schuppner@nuclear.energy.gov

b. Advanced Technologies for the Fabrication, Characterization of Nuclear Reactor Fuel

Improvements and advances are needed for the fabrication, characterization, and examination of nuclear reactor fuel. Advanced technologies are desired for advanced light water reactor fuels and materials and for particulate based TRISO fuels for Advanced Gas-Cooled Reactors/NGNP applications [2, 3, 5, 6]. In the area of light water reactors, specific technologies that improve the safety, reliability, and performance in normal operation as well as in accident conditions are desired.

(1) Provide new innovative LWR fuel concepts, to include fuel and/or cladding, with a focus on improved performance (especially under accident scenarios), develop radiation-tolerant electronics for characterization instrumentation for use in hot cell fuel/cladding property measurements or characterization. Improvements to LWR fuel and cladding may include but not be limited to fabrication techniques or characterization techniques to improve the overall performance or understanding of performance of the nuclear fuel system.

(2) Develop advanced automated, accurate, continuous vs. batch mode process techniques to improve TRISO particle fuel and compacts to include: (a) improved fabrication methods for TRISO fuel kernels, particle coatings and compacts, automated fabrication and characterization methods to replace manual manufacturing techniques, and (b) advanced methods for non-destructive evaluation testing of TRISO particles and compacts for demonstration.

(3) Develop improved fabrication methods for sodium fast reactor fuels and cladding materials, especially for uranium based metallic and oxide fuel.

Grant applications may use non-fueled surrogate materials to simulate uranium, plutonium, and minor actinide bearing fuel pellets or TRISO particles for demonstration. Actual nuclear fuel fabrication and handling applications which require use of the INL ATR National Scientific User Facility [4], and its hot cells and fuel fabrication laboratories, or the Oak Ridge National Laboratory Advanced Gas Reactor TRISO fuels laboratory facilities [5, 6] to demonstrate the techniques and equipment developed may be proposed. Actual nuclear fuel specimens may be considered for ATR or ORNL High Flux Irradiation Reactor (HFIR) but will need to prove technical feasibility prior to their insertion into the ATR or HFIR for irradiation testing. Access to the aforementioned facilities is not guaranteed as part of this solicitation and must be obtained independent of an SBIR/STTR award.

Grant applications that address the following areas are NOT of interest and will be declined: thorium based fuels, molten salt based fuels, spent fuel separations technologies used in the Fuel Cycle Research and Development Program [3] and applications that seek to develop new glove boxes or sealed enclosure designs.

Questions – contact: Frank Goldner, Frank.Goldner@nuclear.energy.gov

c. Materials Protection Accounting and Control for Domestic Fuel Cycles

Improvements and advances are needed for the development, design and testing of new sensor materials and measurement techniques for nuclear materials control and accountability (including process monitoring) that increase accuracy, resolution, and radiation hardness, while decreasing intrusiveness on operations and the cost to manufacture. Specifically, concepts and integration of safeguards and security features into design and operation of Used Fuel storage facilities and Electrochemical Recycling facilities are being sought. Grant applications are sought for: (1) Sensors based on radiation detection; (2) Security technologies for Used Fuel dry storage that increase effectiveness and reduce manpower costs; (3) New active interrogation methods; (4) Non-radiation based sensors (stimulated Raman, laser-induced breakdown spectroscopy, fluorescence, etc.). Grant applications are also sought for the development of new methods for data validation and security, data integration, and real time analysis with defense-in-depth and knowledge development of facility state during design.

Detectors that may indicate unauthorized materials diversion can be equally useful in identifying system upsets and the need for control changes. Grant applications are sought for the development of dual-use as well as single purpose instruments and detectors. Proposed concepts used exclusively for separations process control should be submitted under subtopic g.

Grant applications that address border security or remote monitoring are NOT sought.

Questions – contact: Daniel Vega, Daniel.Vega@nuclear.energy.gov

d. Modeling and Simulation

Computational modeling of nuclear reactors is critical for their design and operation. Nuclear engineering simulations are increasingly predictive and able to leverage high performance computing architectures. Writing software which works on leadership class facilities and is able to be used by nuclear engineers in industry presents many challenges. Grant applications are sought that:

Can provide supporting software for nuclear engineering analyses, such as advanced meshing tools (*e.g.*, for generation of reactor spacer grid fluid flow or structural mechanics simulations), advanced visualization tools (*e.g.*, for projecting 1-D network flow simulation results as color maps onto 2-D

graphical icons created by the user), and data exchange capability between codes (*e.g*., for duplication of a large mesh-based data set onto an array of similar, coarser meshes); and
Can integrate the resultant tools and codes into a web services framework, with emphasis on the ability to connect to an open science computing framework like the open science grid.

Questions – contact: Dan Funk, Dan.Funk@nuclear.energy.gov

e. Non-Destructive Examination (NDE) of Materials Used in Nuclear Power Plants

The development of new and innovative ideas to provide non-destructive testing techniques or monitoring technologies for long-term operation and performance of concrete and civil structures in nuclear power plants are needed. Expert panel deliberations identified long-term corrosion and creep of post-tension reinforcement tendons in containment buildings, corrosion of liners for the containment building, and corrosion of liners in spent fuel pools as possible knowledge gaps and areas in need of future development. New techniques, sensors, or monitoring capabilities would support extended service operation. Proposals targeting the performance and integrity of metal components within concrete structures (including rebar, liners, anchors, etc.) are of high interest.

Questions – contact: Richard Reister, Richard.Reister@nuclear.energy.gov

f. Advanced Methods for Manufacturing

A strong manufacturing base is essential to the success of U.S. reactor designs currently competing in global markets, but the success of the Small Modular Reactor (SMR) Initiative depends heavily on the ability of the U.S. to deliver on the SMR's expected advantages – the capability to manufacture them in a factory setting, dramatically reducing the need for costly on-site construction – thereby enabling these smaller designs to be economically competitive.

Several areas are appropriate for development by small businesses.

Advanced fabrication and manufacturing methods will require advances in welding processes and inspection methods that can maintain production speed and efficiency with the manufacturing processes. Component manufacturing technologies will be required that take full advantage of the new 3-D printing methods employed by Additive manufacturing technologies. These manufacturing methods must be capable of producing components or sub components on a limited production basis and with nuclear quality. Grant applications are sought for (1) methods to improve the process, speed, quality and cost of welding and the required in-process and post welding inspections and (2) methods and processes to fabricate components using advanced technologies like 3D printing forms of Additive manufacturing processes that can eventually produce nuclear quality components. Grant applications are also sought for methods that can improve the manufacturing processes required for nuclear components using "Just in time" manufacturing methods adapted from other industries.

Data and resource management programs are currently being considered by reactor vendors and their EPC contractors for the construction of new nuclear power plants. New nuclear plant owners will be required to manage and control the configuration of the nuclear plant through the complete nuclear plant lifetime. Significant project cost and schedule advantage can be achieved by effectively managing and maintaining configuration management (CM) of plant data beginning in the design and construction phases of the nuclear plant. Advanced methods are needed to acquire process and compare construction as-built configurations against the design. Grant applications are sought for (1) methods and technology improvements in laser, GPS and photometric systems to assure the as-built configuration matches the design, and (2) improvements in radiofrequency (RF) tags and similar devices to assure correct materials, placement, test criteria, and spare parts inventories.

Questions – contact: Alison Hahn, Alison.Hahn@nuclear.energy.gov

g. Material Recovery and Waste Forms for Advanced Domestic Fuel Cycles

Material recovery and waste forms play critical roles in both current and future nuclear fuel cycles. Currently, research reactor fuels are being processed in the U.S. for their stabilization while large nuclear waste treatment processing plants are in operation and are being constructed to convert cold war liquid waste into safely storable solid waste forms. An additional plant is being built to convert weapons-grade plutonium into commercial nuclear fuel. In the future, chemical processing plants may be constructed in the U.S. to recycle used nuclear fuel for improved resource utilization and reduced environmental impact. In all cases, modest improvements in chemical processing technologies can effect significant cost reductions.

In addition to the use of advanced sensors and measurement technologies for materials protection, accounting and control (as outlined in subtopic c), grants are sought for the development of related systems useful for material recovery process control. For example, detectors that may indicate unauthorized materials diversion can be equally useful in identifying system upsets and the need for control changes. Grant applications are sought for the development of dual-use as well as single purpose instruments and detectors used exclusively for process control. However, proposals that are focused on materials protection, accounting and control related applications are more appropriate for subtopic c and should be submitted there.

Most liquid high-level nuclear waste in the world is being converted to a solid form as a borosilicate glass. Such waste forms, while extremely durable, generally contain low concentrations of radioactive materials. Several approaches are under investigation to increase radioactivity concentrations and thus to decrease the total waste mass and volume for storage and disposal. Examples include the possible use of metal alloys and ceramics as advanced waste forms. Innovations are needed in waste forms chemistry and crystallinity to increase waste concentrations without the sacrifice of glass durability. Acceptability of such new waste forms as alternatives to borosilicate glass will depend upon sufficient knowledge of their degradation processes to be able to predict their performance over geologic time periods. Collaboration with national laboratory scientists involved in related studies is encouraged.

Questions – contact: James Bresee, James.Bresee@nuclear.energy.gov

h. Control System Modernization for Research Reactors

The Department is seeking applications for the development of a detailed design to modernize control systems for aging research reactors. It is envisioned that this work will be demonstrated on the Advanced Test Reactor Critical Facility (ATRC) at the Idaho National Laboratory (INL). In an effort to expedite development of a modern control system design, the Department is encouraging "Fast-Track" Applications for a combined Phase I and Phase II award.

The ATRC at Idaho National Laboratory is a low-power reactor designed and constructed in the early 1960s. The mission of the ATRC is to obtain accurate and timely data on nuclear characteristics of the ATR core such as rod worths and calibrations, excess reactivities, neutron flux distributions, gamma-heat generation rates, fuel loading requirements, and effects of insertion and removal of experiments. The ATRC typical operating power level is 600 Watts (W) or less, with a maximum allowable power of 5kW. The core is cooled via natural convection of light water, is light water moderated and reflected by beryllium. Some of the ATRC-generated information is used to ensure that the Advanced Test Reactor (ATR) core, 250 MWth, can be operated safely within its safety basis envelope during performance of various nuclear research activities.

The majority of the existing ATRC control system is original 1960's or early 1970's vintage equipment and is well beyond its expected product life cycle. Spare parts availability and technical support for much of the instrumentation and control (I&C) equipment currently in use at ATRC is virtually nonexistent, making continued operation and maintenance extremely difficult. The goal of this workscope is to design a reliable I&C system for operation of ATRC for 15 to 20 years following system replacement.

The work scope includes the design changes necessary to make the reactor shutdown system compliant with current standards and requirements, but limits the application of digital processor technology to non-safety functions. All safety class functions would continue be performed with analog I&C components. The applicant must also be able to meet all applicable access and quality assurance requirements.

This detailed design effort would include the following systems:

- Reactor Shutdown System (RSS)
  - Neutron Level Subsystem
  - Log-N/Period Subsystem
  - Manual Scram Subsystem
  - Scram Logic Subsystem
- Log Count Rate Meter (LCRM) System
- Non-RSS Scram System
  - Seismic Switch Subsystem
- Rod Control System
  - Safety Rod Controls Subsystem
  - Outer Shim Controls Subsystem
  - Neck Shim Controls Subsystem

  - Neutron Start-up Source Control Subsystem
  - Control Element Drive Interlock Function Subsystem
- Digital Reactivity Measurement System
- Annunciator System and Indicator Lights System

Questions – contact: Jason Tokey, Jason.Tokey@nuclear.energy.gov

i. Fuel Resources

For nuclear energy to remain a sustainable energy source, there must be assurance that an economically viable supply of nuclear fuel is available. Although uranium is present in very low concentrations in seawater (3.3 part per billion), the oceans contain over 4,500 million tons of uranium, which would last for centuries even with aggressive nuclear energy growth. Economic extraction of uranium from seawater could ensure a feasible fuel supply for nuclear power for millennia to come. Grant applications are sought in (1) development of new polymer sorbents via surface grafting techniques; (2) design and synthesis of functional ligands; (3) development of advanced adsorbent materials; and (4) development of innovative elution processes to improve adsorbent durability. Grant applications will be accepted that address uranium extraction from unconventional resources.

Questions – contact: Stephen Kung, Stephen.Kung@nuclear.energy.gov

j. Cybersecurity Technologies for Protection of Nuclear Safety, Security, or Emergency Response Components and Systems

As future nuclear energy components and systems become more dependent upon digital technologies, reactor operators will become more dependent upon cybersecurity technologies that protect the integrity and reliability of these digital technologies. Safe, secure, reliable and cost effective products are needed to ensure operators that nuclear energy components and systems are secure from cyber attacks or that their systems can significantly mitigate the consequences of an attack. Proposals are requested for technologies that will detect or protect against attacks that could alter or extract data, induce unsafe conditions or disable operations. Technology solutions are sought that are designed specifically to address cybersecurity challenges to uniquely-nuclear components and systems that are integrated with the digital and communication interfaces to protection, monitoring, safety, security, safeguards, balance-of-plant, and/or emergency response systems.

Questions – contact: Trevor Cook, Trevor.Cook@nuclear.energy.gov

k. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Bradley Williams, Bradley.Williams@nuclear.energy.gov

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Subtopics a-g

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33. ADVANCED TECHNOLOGIES FOR NUCLEAR WASTE

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Storage of used nuclear fuel is occurring for longer periods than perhaps first intended. This being the case it is desirable to address technical performance issues of the nuclear materials with time. Improvements and advances for the development, design, and testing of new sensors, transmitters, and measurement techniques for used nuclear fuel stored in dry storage systems for long periods of time could be beneficial. While long-term material performance studies are planned within the Used Fuel Disposition (UFD) program, there are limited opportunities to perform reliable real-time monitoring of the material condition in a sealed container or a dry storage cask. There are several monitoring devices that can be used for conventional non-destructive examinations. However, the current monitoring devices only provide limited information and the long-term reliability of the data could be questionable. Of interest to the UFD program are grant applications that propose new devices based on the long-term material behavior characteristics and/or propose new data collection and advance analyses methods that can support reliability of long-term storage options.

Grant applications are sought only in the following subtopics.

a. New Technology for Devices for Evaluating Internal Conditions of Nuclear Waste Storage Casks Nondestructively

Grant applications are sought: (1) to improve and optimize instrumentation devices using advanced techniques that relate to the fundamental properties of degrading nuclear materials, Develop a monitoring system for internal conditions in used fuel dry storage systems to identify or predict fuel cladding failure and fuel assembly structural degradation/corrosion [1, 2, 3, 4]. The attributes to be monitored might include radiation levels, temperatures, pressures, detection of certain gasses including corrosion products and radioactive decay elements, etc. (2) Develop remote and long-term monitoring of nuclear waste casks in a passive manner. The monitoring sensors might be located inside the containment canister or externally, depending on the proposed measurement technique. If internal, there shall be no penetrations through the canister; they would have to be powered without direct connections and the signals would have to be transmitted without direct connection (through thick steel shells and, possibly, concrete over-packs). The sensors and transmitters would have to sustain harsh environments (including high radiation, high temperatures, and vibration) for long periods of time (centuries) without accessibility for maintenance or calibration. The sensors and transmitters would have to sustain reorientation and vibration associated with loading and shipping the used fuel canisters from the reactors to the storage facilities. There might be several ways to solve each of these requirements. (3) Develop sensing technology to record and warn operators of events exceeding threshold of preset damage values for internals of a waste containing casks.

Questions – contact: John Orchard, John.Orchard@nv.doe.gov

b. Advanced Data Analyses Methodology for Nuclear Waste Containers/Casks Currently in Use

There are several monitoring devices that provide data based on interpretation of physics, chemistry, or radiological aspects of the material/structure performance. These data very often get filtered or amplified for purposes of identifying a phenomenon under consideration. However the raw data may contain additional information that could be valuable, if one is able to perform detailed or new analyses of these data. Grant applications are sought: (1) to develop methodology to extract more usable information from current monitoring devices for material degradation processes, and (2) develop and demonstrate advanced data analysis schemes with the use of multiple devices of various kinds.

Questions – contact: Prasad Nair, Prasad.Nair@nv.doe.gov

c. Chlorine Induced Stress Corrosion Cracking

Chlorine induced stress corrosion cracking (SCC) in stainless steel (SS) dry storage canisters is an issue that the U.S. regulator, industry, and DOE is addressing. In particular, there are issues associated with conditions that initiate corrosion and resultant crack growth, as well as crack growth rate. Understanding the drivers for crack growth rate in used fuel dry storage casks is especially important as it will provide guidance on time intervals required to conduct canister inspections. Grant applications are sought to: (1). Investigate general SCC in SS canisters and weldments, and (2) investigate specific crack growth rates associated with SCC in SS canisters and weldments.

Questions – contact: Prasad Nair, Prasad.Nair@nv.doe.gov

d. Used Fuel Disposition, Generic Repository Research and Development: Deep Boreholes

New methods and technologies could address key issues that affect the future of nuclear energy, in particular, resolution of materials disposition associated with the back-end of the nuclear fuel cycle. A further challenge is the dispositioning of defense program high-level nuclear waste products and used nuclear fuel from civilian reactors. The U.S. DOE Office of Nuclear Energy, Office of Fuel Cycle Technologies, Office of Used Nuclear Fuel Disposition R&D [1,2, 3] is currently investigating generic repository disposal systems in crystalline/granite, shale, salt, and deep borehole environments.

Proposals are sought in the following general areas.

Improvements and advances in drilling and testing technologies, and understanding of generic deep borehole environments (drilled to 5 km depth into "crystalline basement" rock) are sought; consideration should be given to examination of the feasibility of using existing drilling and testing systems and component technologies and innovative techniques to provide information to be used in the design, construction, testing, characterization, and performance assessment modeling of the deep geologic system borehole environment (chemical, hydrologic, mechanical, thermal).

Deep borehole (3-5km depth, crystalline basement rock) disposal of nuclear waste [4-19] has been considered by several nations. Research and development challenges provide opportunities for contribution to the USA's ongoing efforts in this area including but not limited to:

- Seal integrity studies,
- Canister design and prototyping,
- Drill rig design specifications / modification for emplacement,
- Bentonite and cement degradation evaluation,
- Borehole, casing, and liner design and emplacement operations,
- Waste form degradation studies at expected environmental conditions,
- Selected radionuclide (I129, Tc99, Cl36) characterization at expected environmental conditions,
- Studies of I129 sorbent additive in seal zone: system modeling investigations to examine long-term (up to 1 million years) changes in system processes and performance for deep basement rock environments
- Age dating methods and reliability for very old groundwater (millions to billion years); including test specifications, materials, hardware requirements, test methods, distinguishing age of pore waters and fracture waters or determination of hydrologic system character and formation water residence time [19-23].

Proposals are sought to evaluate, improve, and or optimize the reliability, accuracy, and/or performance of drilling technologies and instrumentation, testing methods and applications, and modeling or analysis of deep borehole systems. Predictive and post-testing computational component, process, and system modeling and simulations are important for confidence building; it may also be advantageous to leverage high performance computing architectures and capabilities. Of particular interest are applications that propose the use of cooperative research efforts (e.g., with the national laboratories, other research institutions) in examination of the deep borehole disposal option; proposals are invited in other areas that fall within the scope of the topics described above.

Questions – contact: Mark Tynan, Mark.Tynan@nv.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact: Joe Price, joe.price@doe.gov

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