# U.S. Department of Energy

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

# Topics

## FY 2012
## Phase I
## (Release 2)

**January 6, 2012**

**Participating DOE Research Programs**

- Office of Defense Nuclear Nonproliferation
- Office of Electricity Delivery and Energy Reliability
- Office Energy Efficiency and Renewable Energy
- Office of Environmental Management
- Office of Fossil Energy
- Office of Nuclear Energy

**Please Note:** **the Following Important Dates Pertaining to these Topics and the FY 2012 SBIR/STTR Phase I (Release 2) Funding Opportunity Announcement (FOA). All dates are preliminary and subject to change.**

| | |
|---|---|
| · Topics Released: | November 1, 2011 |
| · FOA Issued: | November 28, 2011 |
| · Letter of Intent Due Date: | December 20, 2011, 11:59 PM EST |
| · Application Due Date: | January 31, 2012, 11:59 PM EST |
| · Award Notification Date: | May 2012 |
| · Start of Grant Budget Period: | June 2012 |

| Change Control Table | |
|---|---|
| | **Change** |
| **1** | a. Correct email address: alan.schroeder@ee.doe.gov |
| | b. Correct Topic 10a reference link: http://www1.eere.energy.gov/biomass/pdfs/cookstove_meeting_summary.pdf |
| | c. Correct email address: Travis.Tempel@ee.doe.gov |
| **2** | a. Reactivate Topics Table of Contents |
| | b. Reactivate "PROGRAM AREA OVERVIEW: OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY" link. |
| **3** | Revise Topic 10a description, "Clean Biomass Cookstove Technologies" to emphasize "domestic" testing, evaluation, and deployment. |
| **4** | a. Correct Table of Contents to depict all four Subtopics under Topic 17. |
| | b. Cancel Topic 4, "Radiological Source Replacement" |
| | c. Change Topic 2 Manager from Frances Keel to David LaGraffe, |
| | d. Make minor edits to first paragraph of Subtopic c, Topic 17. |

## 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 Office of Nonproliferation and Verification Research and Development Program reduces the threat to national security posed by nuclear weapons proliferation and detonation or the illicit trafficking of nuclear materials through the long-term development of new and novel technology. 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. The Nonproliferation and Verification R&D program is comprised of two subprograms: Proliferation Detection and Nuclear Detonation Detection.

The Proliferation Detection subprogram advances basic and applied technologies for the nonproliferation community. Specifically, the subprogram 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 subprogram 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. This subprogram also conducts research and development on nuclear detonation forensics, improvements in satellite operational systems to meet future requirements and size and weight constraints, and radionuclide sampling techniques for detection of worldwide nuclear detonations.

For additional information regarding NNSA's overall nuclear nonproliferation activities, including, research and development, click here.

### 1. ADVANCED SEPARATIONS OF LANTHANIDES

Separations chemistry is practiced broadly for a variety of applications related to DOE missions. These applications range from environmental sampling and analysis of trace constituents to nuclear forensic analysis of radioactive samples. New chemical separations methods are needed to enable researchers to rapidly and reproducibly isolate several chemical species of interest that are in liquid mixtures at low concentrations. Advances in technical tools that perform efficient separations can directly impact the pace and extent of scientific study of species that are in low concentrations but whose presence, if detected and quantified, has significant diagnostic value.

**Grant applications are sought in the following subtopics:**

## a. Efficient Lanthanide Separations

In particular, lanthanides (elements with atomic numbers 57-71) are strategic materials for emerging renewable energy applications, with current commercial uses (e.g., in semiconductor manufacturing) that drive the economic viability of mining, refining, purification, and recycling and recovery operations (DOE, 2010). Lanthanides are also of interest to separate from other species in aqueous radioactive waste process steps. They are also diagnostically useful in nuclear materials applications, in assays of spent nuclear fuel and in nuclear forensics analyses. In such applications, efficient chemical separations are of value to improve the extraction of lanthanides from solutions that contain multiple species, including non-lanthanide elements. Presently available separations methods (e.g., based on ion exchange or extraction chromatography) can isolate lanthanides from non-lanthanides, and further segregate separate lanthanide species, only via time-intensive steps, because of limitations to the inherent quality of separations (expressed in terms of relevant figures of merit such as decontamination factors and equilibrium constants). Grant applications are sought for technologies that are better than current methods in their selectivity for one or more lanthanides. Such technologies would enable more efficient separations methods to (a) isolate lanthanides from other elements (e.g., actinides and transition metals) in solution, and/or (b) improve intra-group separations (i.e., isolating one lanthanide element from others), in solutions that contain multiple species.
Questions – contact Thomas Kiess, Thomas.kiess@nnsa.doe.gov

## b. Development of Resin Material Binders Compatible with Emerging Highly Selective Ligands

Extractions of lanthanides (or actinides) that now use phenanthroline-derived quadridentate bis-triazine ligands (Lewis et al, 2011) are of interest to perform in ways that are more efficient – that is, that are more rapid, and/or that achieve a high degree of separation between the analytes that this ligand sequesters and other species in the original liquid mixture. These efficiencies can be obtained by the development and use of an appropriate resin (binder) material that is compatible with this ligand and that enables it to be used in a column, for use in extraction chromatography.

Currently such ligands are used in solvent extraction (SX) methods. SX is not a rapid method of separation, nor is it an environmentally friendly process as large amounts of toxic solvents are used. The binding of this ligand to a solid support could greatly increase the ease and speed of the separation.

Grant applications are sought for the development of a resin material that incorporates this ligand in the surface area of an extraction column. Properties of interest include minimal degradation of the ligand performance in its degree of separations (e.g., as measured by decontamination factors in comparison to SX or batch mode tests), flow-through rates, and the rapidity of separations achieved with the new resin. Separations of interest to test are the extraction of lanthanides and/or actinides (whole groups or selected elements) from potential chemical interferents.

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

**References**

**Subtopic a:**


1. (DOE, 2010) U.S. Department of Energy Critical Materials Strategy, December 2010, www.energy.gov
2. Payne, R. F. et al, J. Radioanal. Nucl. Chem. (2011) 287: 863-867.
3. Deepika, P.. Sivaraman N., Sabharwal K. N., et al., Radiochimica Acta 99 (6) 325-334 (2011).
4. Schwantes, J.M., Rundberg, R.S., Taylor, W.A., et al, J. Alloys Compd. 418 (1-2) 189-194 (2006).
5. United States Patent 4867951
6. United States Patent 5826161.


**Subtopic b:**


1. (Lewis et al, 2011) Lewis, F. W., L. M. Harwood, M. J. Hudson, M. G. B. Drew, J. F. Desreux, G. Vidick, N. Bouslimani, G. Modolo, A. Wilden, M. Sypula, T-H. Vu, and J-P Simonin, Highly Efficient Separation of Actinides from Lanthanides by a Phenanthroline-Derived Bis-triazine Ligand, J. Am. Chem. Soc. 2011, 133, 13093-13102.
2. http://eichrom.com/radiochem/
3. Lanthanide and Actinide Chemistry, S. Cotton (John Wiley & Sons, Ltd., 2006).


## 2. GLOBAL SAFEGUARDS

The Global Safeguards Program supports NNSA's nuclear nonproliferation mission by developing innovative safeguards technologies to verify the correctness and completeness of declarations regarding nuclear materials. The program develops technologies to detect diversion of nuclear material from declared facilities; to detect undeclared nuclear material and activities; and to verify compliance with safeguards agreements related to the control, production, or processing of nuclear material. This includes the verification that declared facilities have been constructed and remain as declared, and the verification that undeclared facilities do not exist. The program includes R&D in nuclear (and relevant nonnuclear) measurements, information integration and management, advanced tools for systems analysis, authentication, and containment and surveillance technology.

**Grant applications are sought in the following subtopics:**

### a. Verification of Declared Facilities and Discovery of Undeclared Facilities

Grant applications are sought for the development of a reliable and robust ground penetrating imaging system with high resolution, for the purpose of identification and verification of underground facilities. Inspectors must be able to quickly verify that declared facilities at inspection sites are constructed as declared by the operator, and ensure that there are no undeclared facilities present. Grant applications must show a clear link between the proposed technology and the ability to identify and verify underground facilities.

Questions – contact: Frances Keel, frances.keel@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: Frances Keel, frances.keel@nnsa.doe.gov

**References**

**Subtopic a:**


1. "Safeguards to Prevent Nuclear Proliferation." March 2009. (Full text available at: http://www.world-nuclear.org/info/inf12.html).
2. "The US Support Program to IAEA Safeguards." Modified June 5, 2008. (URL: http://www.bnl.gov/ISPO/ussp.asp).
3. "Safeguards R&D Program in the United States." Presented at the 50th Anniversary meeting of Institute for Nuclear Materials Management, July 2008.
4. Daniels, David J. (2004). Ground Penetrating Radar (2nd Edition).. Institution of Engineering and Technology. Online version available at: http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=1244&VerticalID=0.


## 3. RADIATION DETECTION

The Office of 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 development 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. The objective of this topic is to gain insight into a mechanistic understanding of material performance as the base component of radiation detectors. That is, the program is interested in moving beyond the largely empirical approach of discovering and improving detector materials to one based on a clear understanding of basic materials properties.

**Grant applications are sought in the following subtopics:**

## a. Scintillators for Gamma Spectroscopy

Grant applications are sought to support research on materials that will lead to practical high-brightness scintillators with energy resolution significantly better than the currently available sodium iodide-based gamma spectrometers. Several new and promising formulations have been discovered and synthesized in small quantities, but there is a need for industrial crystal-growth facilities to find ways to produce practical sizes of high-quality scintillators at a reasonable cost. As an alternative to crystal growth, techniques that produce high quality, large volume scintillators with good spectroscopic performance from the consolidation of powders are highly desirable. Moreover, a scintillator thick enough to absorb high energy gamma rays must also be very transparent to its own emitted light. A laboratory demonstration is expected in Phase I, while Phase II should lead to the development of a commercial process with a significant advantage over current crystal growth techniques.

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

## b. Semiconductors for Gamma Spectroscopy

We are interested in promoting the industrial capacity to develop large volume, high quality radiation detector materials based on semiconductors that operate at ambient temperature. Approaches of interest must address growth issues involving such semiconductor materials, so that reliable, high yield, rapid and large volume growth is readily achievable at a reasonable cost. It should be recognized that good electronic transport properties are essential, such as electron and hole mobilities and lifetimes, which as a rule require extremely low concentrations of deleterious impurities and careful control of deliberate dopants. Phase I should result in the identification of new materials or of a clear path to improving upon existing growth techniques. Phase II should include a demonstration of a material fabrication process that is free from dislocations, cracking, chemical heterogeneities, and minor crystalline phases, including precipitates.

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

**c. Advanced Organic Materials**

New organic solid materials capable of detecting fast neutrons and distinguishing them from gamma rays are of interest to the program. Important criteria for fast neutron detection devices are intrinsic efficiency for fission spectrum neutrons and pulse timing precision, as well as good gamma rejection ratio. These materials would replace liquid scintillators in a number of applications important to nonproliferation. Phase I would establish a pathway to production of significant quantities of detector material, while making use of materials supplied by NNSA laboratories. Phase II would expand the technology beyond the scale of individual exploratory experiments to the stage of employing kilogram quantities of high quality neutron detecting material in large detectors or arrays of modules.

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

**d. Laser Plasma Accelerators**

Researchers are developing novel laser-plasma accelerators (LPAs) whose compactness and versatility offer exciting prospects for fieldable systems to actively interrogate targets which may contain special nuclear materials. These systems provide electron beams with energies of 0.1-1.0 GeV and percent-level energy spread in cm-scale distances. Such electron bunches can produce bright, mononergetic pulses of MeV gamma rays for active interrogation via Compton scattering. The objective of this topic is to dramatically advance the state-of-the-art in laser-plasma accelerator technology for compact, fieldable gamma ray active interrogation sources. Near-term priorities for further development include improved electron beam quality and the associated diagnostics, and improved shot-to-shot reliability of LPA operation. Optimization of the gamma-ray generation processes, including Compton scattering of a laser pulse off the electron bunch, and related radiation processes is also essential to future success. The mid-term objective is to move from the study of LPA experiments to the development of reliable, turnkey systems. The long-term objective is to increase the rep rate and decrease the cost of such systems. Plasma target development is required to improve LPA performance and reliability. This includes suppression of shot-to-shot and spatial fluctuations in plasma parameters, as well as radial tailoring of density to guide the laser, and/or longitudinal tailoring to induce injection and to facilitate laser coupling.

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. N. J. Cherepy, B. W. Sturm, O. B. Drury; T. A. Hurst. S. A. Sheets, L. E. Ahle, C. K. Saw, M. A. Pearson, S. A. Payne, A. Burger, L. A. Boatner, J. O. Ramey, E. V. van Loef, J. Glodo, R. Hawrami, W. M. Higgins, K. S. Shah, W. W. Moses, "SrI2 scintillator for gamma ray spectroscopy ," Proc. SPIE, 7449, 7449-0 (2009).
2. Bessiere, P. Dorenbos, C. W. E. van Eijk, K. W. Kramer, H. U. Gudel and A. Galtayries. Scintillation and anomalous emission in elpasolite Cs2LiLuCl6 : Ce3+. *Journal of Luminescence*, 117:187-198, 2006.


**Subtopic b:**


1. A.E. Bolotnikov, S.O. Babalola, G.S. Camarda, H. Chen, ; S. Awadalla,; Cui Yonggang, S.U.Egarievwe, P.M. Fochuk, R. Hawrami, A. Hossain, J.R. James, I.J. Nakonechnyj, J. Mackenzie, Ge Yang, Chao Xu, R.B. James, *IEEE Trans. on Nucl. Sci*., 56(4), 1775 (2009) "Extended Defects in CdZnTe Radiation Detectors".
2. Robert C. Runkle, L. Eric Smith, and Anthony J. Peurrung, "The photon haystack and emerging radiation detection technology", *J. Appl. Phys.* 106, 041101 (2009).


**Subtopic c:**


1. Natalia Zaitseva, Leslie Carman, Andrew Glenn, Jason Newby, Michelle Faust, Sebastien Hamel, Nerine Cherepy, Stephen Payne, *J. Crys. Grow.* 314, 163 (2011).
2. Natalia Zaitseva, Jason Newby, Giulia Hull, Cheng Saw, Leslie Carman, Nerine Cherepy, Stephen Payne *Cryst. Growth Des.*, 9 (8), 3799 (2009).


**Subtopic d:**


1. W. P Leemans, B. Nagler, A. J. Gonsalves, C. Toth, K. Nakamura, CGR Geddes, E. Esarey, C. B. Schroeder, and S. M. Hooker, Nature Physics, 2, 696 (2006).


## 4. ~~RADIOLOGICAL SOURCE REPLACEMENT~~ – TOPIC CANCELLED

~~The Radiological Source Replacement Program seeks to mitigate the risk from accidental release or malicious use of commercial radioisotope sources, such as those found in medical irradiation systems, well logging applications, sterilization systems (for equipment, food, and insects), and industrial non-destructive testing and evaluation equipment. The program includes R&D to develop alternative technologies that can replace or improve the functional capability of these systems without the use of radioisotopes.~~

**~~Grant applications are sought in the following subtopics:~~**

**a. ~~Non-Destructive Testing and Evaluation~~ – Subtopic Cancelled**

~~Grant applications are sought to develop technologies to enable the replacement of radioisotope sources, while maintaining or improving the functional capability of industrial non-destructive testing and evaluation systems, including, but not limited to testing of feedstock, final products, and *in situ* inspections of equipment and installations. Also included are new techniques that improve the imaging capabilities of existing non-isotope based portable nondestructive evaluation systems, to motivate their adoption by commercial industries. Grant applications must show a clear link between the proposed technology and the functional capability of the radioisotope system it would replace, or a clear improvement in the imaging capability.~~

Questions – contact: David LaGraffe, david.lagraffe@nnsa.doe.gov

**b. ~~Replacement of Radioisotope-Based Neutron Sources~~ – Subtopic Cancelled**

~~Grant applications are sought to develop technologies that can replace radioisotope-based neutron sources. Such sources, often containing Californium-252, Americium-241, or other radioisotopes, are widely used in industries such as oil well logging and cement or coal production for density and porosity measurement and neutron activation analysis, respectively. The industrial environment causes significant constraints (i.e., high temperature, high pressure, dust, vibrations, and limited accessibility) that must be addressed. Grant applications must show a clear link between the proposed technology and its ability to provide neutrons in an industrial environment.~~

Questions – contact: David LaGraffe, david.lagraffe@nnsa.doe.gov

**c. ~~Transportation Security Technology~~ – Subtopic Cancelled**

~~Grant applications are sought to develop technologies for monitoring packages in storage and during transportation, including the communication of status, geo-referenced location, environmental changes, and alarms, and the capability to monitor up to thousands of co-located packages simultaneously. The monitoring and communications system must be able to be applied to standard drum and bolted closure packages, and must be useable without voiding the package certification. Grant applications must show a clear link between the proposed technology and an improvement in transportation security.~~

Questions – contact: David LaGraffe, david.lagraffe@nnsa.doe.gov

**d. ~~Other~~ – Subtopic Cancelled**

~~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 LaGraffe, david.lagraffe@nnsa.doe.gov

**~~References~~**

**~~Subtopic a, b, and c:~~**


1. ~~"Radiation Source Use and Replacement." The National Research Council. The National Academies Press, Washington D.C., 2008. (Available at http://www.nap.edu/catalog/11976.html).~~
2. ~~"Report on Alternatives to Industrial Radioactive Sources." Department of Energy Report to the U.S. Congress, Under Public Law 109-58, *The Energy Policy Act of 2005,* August 1, 2006.~~
3. ~~"Security in the Transport of Radioactive Material," IAEA Nuclear Security Series Number 9. International Atomic Energy Agency. Vienna, 2008. (Full text available at: http://www-pub.iaea.org/MTCD/publications/PDF/pub1348_web.pdf).~~
4. ~~"Industrial Radiography," General Electric Company. 2007. (Available at: http://www.ge-mcs.com/download/x-ray/GEIT-30158EN_industrial-radiography-image-forming-techniques.pdf)~~


## 5. REMOTE SENSING

For decades, the Remote Sensing Program has been a cornerstone in the national capability for the detection of facilities and activities related to the proliferation of foreign nuclear programs. The Remote Sensing Program research projects encompass a wide variety of potential capabilities to detect signatures associated with the development of nuclear weapons. The research areas in the Remote Sensing program include sensor development, image processing, and digital signal processing techniques for characterization of observed phenomena.

**Grant applications are sought in the following subtopics:**

### a. Improvement in Quality of II-VI and III-V Semiconductor Materials for IR Focal Plane Arrays

The ability to grow defect-free materials could conceivably enhance the performance and reliability of constituent photodiodes in II-VI and III-V infrared imaging focal plane arrays, such as HgCdTe and Sb-based SLS. As in any semiconductor device, elimination of defects and anomalies in the underlying material system will enhance device quality and performance, yielding improved focal plane arrays. Applications are sought to enable refinements in focal plane array technology, systematically and routinely through any relevant strategies, including but not limited to, application of advanced analytical imaging methodologies and evaluation of the impact of defects and anomalies on FPA performance and lifetime. Partnership with II-VI / III-V vendors or National Labs may be desirable to access sample test articles.

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

### b. Advance Cooling for IR Detectors

Applications are sought to develop compact, advanced cooling systems capable of lifting ≥ 500 mW at 45 K for next-generation MWIR and LWIR hyperspectral imaging systems. Sensor applications require very low power consumption (< 15 watts) and high reliability (MTTF > 10,000 hours). Design flexibility is desired to support a range of needs.

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

**c. Solid Material Detection Strategies for Hyperspectral Imaging Applications**

Recent efforts to characterize the spectral properties of solid materials in the infrared and visible spectrum have identified significant variability with substrate, particle size, morphology and environmental conditions. We seek the development of experimental and/or numerical methods to advance our ability to interpret the reflectance and emittance spectra of mixed solid-phase materials, either as powders, films, or infiltrated into substrates of various degrees of porosity. In particular, we seek instrumental methods and hardware to allow measurement of complex (n, k) refractive indices of powders or complex multi-component solids, and/or computational tools to predict the spectral reflectance of complex solids such as mixed-material solids, powders, or powders on mixed-material solids.

The result of this project may be a compact goniometric spectral system to rapidly measure the reflectance and emission BRDF of small samples of material or a physics-based model capable of predicting these BRDFs once parameters such as substrate types, target materials, particle size, relative humidity, and other environmental factors are provided. Provider must be willing to work closely with national laboratory researchers and with DOE data sets to develop their instruments or models.

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

**d. High-Speed Photon Counting Devices and Enabling Technologies**

Megapixel-class imaging systems with single-photon sensitivity, high time resolution (sub-ns) of each detected photon, and the capability to detect and process high photon rates (above $10^8$ detected photons per second) are highly desirable for a number of application areas. The NA-22 remote sensing program seeks research and development on full sensor systems with these capabilities or on enabling technologies for such systems. Examples of enabling technologies are multi-channel (~100) readout electronics including high-density, high-speed (pulse widths ~1 to < 100 ns), low-noise (noise equivalent charge of < 1000 electrons) analog preamplifiers and low-power, high-density, continuously sampling, multichannel ADCs well matched to such amplifiers.

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

**References**

**Subtopics a-d:**


1. J. E. Moersch and P. R. Christensen, "Thermal emission from particulate surfaces: A comparison of scattering models with measured spectra," J. Geophys. Res. **100**, 7465 (1995) ISSN 0148-0227 http://epubs.cclrc.ac.uk/search?s=1554&st=browse-by-serial .
2. M. I. Mishchenko et al, "Electromagnetic scattering by a morphologically complex object: Fundamental concepts and common misconceptions," JQSRT **112**, 671 (2011). **ISSN:** 0022-4073 http://www.sciencedirect.com/science/journal/00224073
3. B. T. Braine and P. J. Flatau, "Discrete-dipole approximation for periodic targets: theory and tests," J. Opt. Soc. Am. A **25**, 2693 (2008). ISSN 0740-3224 http://www.opticsinfobase.org/josab/home.cfm
4. T. Wriedt, "Light scattering theories and computer codes," JQSRT **110**, 833 (2009). **ISSN:** 0022-4073 http://www.sciencedirect.com/science/journal/00224073
5. L.C. Stonehill et al, Cross-Strip Anodes for High-Rate Single-Photon Imaging, 2009 IEEE Nuclear Science Symposium Conference Record, pp 1417 - 1421. http://ieeexplore.ieee.org/xpl/conferences.jsp
6. O.H.W. Siegmund et al, High Performance Cross-Strip Detectors for Space Astrophysics, 2007 IEEE Nuclear Science Symposium Conference Record, pp 2246 - 2251. http://ieeexplore.ieee.org/xpl/conferences.jsp


## 6. TECHNOLOGY TO FACILITATE MONITORING FOR NUCLEAR EXPLOSIONS

The Ground-based Nuclear Explosion Monitoring Research and Development (GNEM R&D) Program in the Office of Nuclear Detonation Detection is sponsored by the U.S. Department of Energy's National Nuclear Security Administration's Office of Nonproliferation and Verification Research and Development. This program is responsible for the research and development necessary to provide the U.S. Government with capabilities for monitoring nuclear explosions. The mission of the GNEM R&D Program is to develop, demonstrate, and deliver advanced ground-based seismic, radionuclide, hydro acoustic, and infrasound technologies and systems to operational agencies to fulfill U.S. monitoring requirements and policies for detecting, locating, and identifying nuclear explosions (see Reference 1) Within the context of one or more of these technologies, research is sought to develop algorithms, hardware, and software for improved event detection, location, and identification at thresholds and confidence levels that meet U.S. requirements in a cost-effective manner. 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. Annual research progress of the GNEM R&D program is available in proceedings posted on-line (see Reference 3).

Grant applications responding to this topic must (1) demonstrate how proposed approaches would complement, and be coordinated with, ongoing or completed work; and (2) address the manufacturability of any instruments or components developed.

**Grant applications are sought in the following subtopics:**

**a. Radioxenon Concentration System**

Applications are sought for a compact, robust xenon concentration system that operates with 110V (15 Amp) power for use in automated radioxenon collection and measurements systems. This technology will advance systems that are used in non-proliferation treaty monitoring technology. There has been significant progress in the field of commercial, portable rapid pressure swing adsorption generators to quickly and efficiently produce oxygen for medical use. This rapid pressure swing technology can be the underlying means for the development of a commercial method to concentrate Xe from the atmosphere. It should be noted that the need is for a concentrator only and not for a whole collection and processing system. Ideally, the system will produce a continuous air stream enriched in xenon to a Xe concentration at least 100 to 1000 times the concentration of the whole air feed stream. Whole air input flow rates up to 100 SLPM are desirable. Both high Xe concentration in the product gas and high recovery of Xe in the feed gas are desirable attributes. Higher product stream efficiencies are more desirable than very high xenon purity in the product stream. The design should also be able to handle whole air as an input stream (i.e., no external water or carbon dioxide removal system required). The system should be capable of operation on 110V (15 Amp) power and operate at or above room temperature (for example 50C).

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

**b. Software for Multivariate Signal Detectors and Phase Pickers**

Grant applications are sought to conduct the feasibility of developing a seismic detection and phase picking software package. A prototype software system in a platform independent language (e.g. Java) will be developed in Phase I and applied to seismic signals from either local, regional or teleseismic events. A mathematical statistical approach will be followed that is grounded in signal physics and Proposals involving non-parametric methods (e.g. artificial neural networks) will not be considered.

In Phase II, a general software detection, phase identification and picking package (including array processing picking tools) will be developed that can be tuned to any signal-of-interest. The main focus will be on detecting and picking primary and secondary seismic phases (e.g. P, S, Lg) and determining statistically valid uncertainties. The software should include both automated as well as interactive features. The package must be general enough that it can be adapted to other signal transients for use in oil field and geothermal field applications, border security and perimeter monitoring.

By way of background, the GNEMRD program has supported research towards the multivariate seismic discrimination of earthquakes and nuclear explosions using a novel mathematical statistics formulation (Anderson *et al.,* 2007). The unifying framework revolves around a single hypothesis-testing approach by forming the general null hypothesis $H_0$: *signal plus noise* and to construct a *p*-value indicating the probability of detection conditional on the observations (e.g. Naiman and Priebe, 2001; Anderson *et al*., 2007). The *p*-value for the detected signal can also be thought of as indicating the typicality index (or degree of membership; McLachlan 1992) that the signal originated from a signal-of-interest. In the *p*-value formulation, a physically based probability model is formulated for each detector under the general null hypothesis of the signature having characteristics of a signal-of-interest. The *p*-values are themselves random variables following a uniform distribution between 0 and 1 under the null hypothesis being true and can therefore be combined in a multivariate setting. For time series not consistent with the null, the *p*-values will cluster around zero. Well-established statistical methods can be used to aggregate the *p*-values in order to form a multivariate probability of detection. The *p*-value framework can be for a detector system for either a single unit consisting of multiple sensors (seismic, acoustic, and electro-magnetic) or a distributed sensor network. The discussion here focuses on seismic detectors (e.g. Withers *et al.,* 1998). Because the window lengths for many of the detectors are small, they can be modified to obtain accurate phase picks and importantly, associated uncertainties (e.g. Zeiler and Velasco, 2009). Uncertainties in phase picks are important in determining formal errors from seismic location algorithms.

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

**References**

**Subtopics a-c:**

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## 7. TOOLS, TECHNIQUES, INFRASTRUCTURE AND DEMONSTRATIONS

The Office of Nuclear Nonproliferation Verification Research and Development is dedicated to enabling the development of the next generation technical capabilities through the Tools, Techniques, Infrastructure and Demonstration Program. The Program researches a wide variety of potential capabilities to improve the tools and techniques available to non-proliferators. One specific area of interest combining results from different sensors to obtain a complete picture of use to an operator. Another is mass spectrometry which is used in many areas of nonproliferation.

**Grant applications are sought in the following subtopics:**

### a. Sensor Data Fusion

Proposals are sought to develop an end-to-end sensor data fusion tool that will significantly improve and streamline data processing and information extraction in support of the proliferation detection mission. Applicants are encouraged to discuss how they will design and quantify system performance using objective measures, including, but not limited to, detection rate, false positive rate, confidence level, computational complexity, computing efficiency, and general applicability. The end product is expected to be easily adapted to real applications by the user community. The four mandatory technical requirements are summarized as follows: 1) Architecture Design: a design of the sensor data fusion tool, from raw data to information, should be laid out. A clear justification and comparison of the design with other similar systems needs be provided. 2) Fusion Techniques: the tool should apply appropriate data fusion schemes and algorithms, if necessary, to expand information completeness, improve its confidence, and even produce the new information that is not seen in a single sensor or single type of sensors. 3) Verification and Validation - the tool must be rigorously verified and validated on a demonstration system, in order to ensure its fidelity and utility. 4) Ease of Use – the tool designed such that data can be easily manipulated, and results can be clearly interpreted by an end-user.

Questions – contact: Mike Ortelli, michael.ortelli@nnsa.doe.gov

**b. Ion Sources for Inorganic Mass Spectrometry**

Mass spectrometry provides key isotopic and elemental measurements for the analysis of actinide materials (U, Pu, etc.) in support of nuclear forensics and nuclear safeguards missions. We are looking to support the investigation of novel approaches for improving ion sources for the measurement of the elemental or isotopic composition of actinide samples. Proposed approaches could either provide benefit to all types of mass analyzers (double focusing, quadrupole, time-of-flight, etc.) or only to a specific type of mass analyzer. The proposed approach should provide clear benefits over existing sources for the measurement of elemental and/or isotopic composition of actinides, either in improvement of sensitivity, precision, freedom from interferences, or reduction or elimination of matrix effects. We are also interested in ideas for improving primary ion sources for secondary ion mass spectrometry (SIMS), including the development of (1) smaller spot size primary ion beams (spatial resolution) with sufficient sensitivity for elemental and isotopic analysis of solid actinide samples and (2) improved reliability and source life time.

Questions – contact: Mike Ortelli, michael.ortelli@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: Mike Ortelli, michael.ortelli@nnsa.doe.gov

**References**

**Subtopic a:**


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## 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.

For additional information regarding the Office of Electricity Delivery and Energy Reliability priorities, **click here.**

### 8. HIGH VOLTAGE DC-LINK POWER CONVERSION SYSTEM FOR ENERGY STORAGE APPLICATIONS

Energy storage systems are becoming more prevalent in electric utility applications by providing value added functions such as frequency regulation, renewable firming, power quality enhancement, and dynamic stability support. The enabling technology that is crucial to these applications is the power conversion system. The power conversion system controls the power supplied and absorbed from the grid to optimize energy storage device performance while maintaining grid stability. Most energy storage systems today offer low-voltage, 3-phase AC output of 480 V with a DC input voltage range of 600 to 1000 V to the inverter. Typically, a transformer is used to step up the 480-$V_{AC}$ output to higher distribution voltages for use on the grid. Advances in utility-scale (greater than 100kW) power conversion system design and topologies including advances in semiconductor switches for use in medium-voltage class application (13.8 or 12.47 kV) are sought for energy storage applications with higher DC-link voltages (greater than 1200 $V_{DC}$).

**Grant applications are sought in the following subtopics:**

#### a. High Voltage DC-Link Power Conversion System

Today's traditional high-power converters are known to have high current requirements due to low DC-link voltages. The higher current translates to increased losses in the system, larger cable size (more copper use), and typically higher cost inverter and transformer designs. It is preferable to decrease the current as much as possible by increasing the DC-link voltage (greater than 1200 $V_{DC}$). A utility-scale converter with power ratings of 100 kW to 1 MVA for a medium-voltage application is anticipated. The final design should show a significant increase in performance, cost reduction, a decrease in footprint, and a reduction in thermal management compared to existing systems.

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

### b. Advanced Semiconductor Switches Modules for High Voltage Energy Storage Systems

The critical components in a power conversion system are the semiconductor switches. They determine the overall performance of the converter including the overall cost and reliability. Within the past decade or so, recent advances in advances in post-silicon or wide-band gap materials have led to the development of devices based on materials such as silicon carbide (SiC) and gallium nitride (GaN). These devices for high-voltage energy storage systems have not been fully evaluated or integrated. A post-silicon-based, advanced power module for use in power conversion systems capable of high-voltage (greater than 1200 $V_{DC}$) operation and rated at 100kW or greater is being sought for utility-scale medium-voltage electric utility applications. The design should show a significant increase in performance (*e.g.,* increased efficiency), cost reduction, an increase in power density, and a reduction in thermal management requirements.

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

**References**

**Subtopic a:**

1. Wade, N., Taylor, P., Lang, P., Svensson, *Energy Storage for Power Flow Management and Voltage Control on an 11kV UK Distribution Network*, 20th International Conference on Electricity Distribution, June 2009. http://ieeexplore.ieee.org/search/freesrchabstract.jsp?tp=&arnumber=5255616&queryText%3DEnergy+Storage+for+Power+Flow+Management+and+Voltage+Control+on+an+11kV+UK+Distribution+Network%26openedRefinements%3D*%26filter%3DAND%28NOT%284283010803%29%29%26searchField%3DSearch+All
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## PROGRAM AREA OVERVIEW: OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

The mission of the Office of Energy Efficiency and Renewable Energy (EERE) is to strengthen America's energy security, environmental quality, and economic vitality through support for the research, development, demonstration, and market deployment (RDD&D) of clean, reliable, and affordable energy efficient and renewable energy technologies for the buildings, industry, transportation, and power sectors.

EERE leads the Federal government's RDD&D efforts in energy efficiency and renewable energy. EERE's role is to invest in high-value RDD&D that is critical to the Nation's energy future and would not be sufficiently conducted by the private sector acting on its own.

Program activities are conducted in partnership with the private sector, state and local government, 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.

For additional information regarding EERE priorities, click here.

### 9. SELECTED ENERGY EFFICIENCY TECHNOLOGIES

The U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy is seeking the development of innovative technologies for: (a) Reliable, Low-Cost, Self-Powered Wireless Sensors for Commercial Buildings; (b) Hybrid Electric Powertrain Systems; (c) Next Generation Processes for Carbonate Electrolytes for Batteries Applications; (d) Advanced Processing of Rare Earth Elements; (e) Distributed Production of Hydrogen from Waste Water; (f) Hydrogen Storage Technologies for Near-Term Fuel Cell Applications.

Grant applications submitted in response to this topic must: (1) include a review of the state-of-the-art of the technology and application being targeted; (2) provide a detailed evaluation of the proposed technology and place it in the context of the current state-of-the-art in terms of performance, lifecycle cost, reliability, and/or other key attributes; (3) analyze the proposed technology development process, the pathway to commercialization, the large potential markets it will serve, and the attendant potential public benefits that would accrue; and (4) address the ease of implementation of the new technology.

Phase I should complete (1) a preliminary design, (2) a characterization of laboratory devices using the best measurements available, including a description of the measurement methods, and (3) the preparation of a road map with major milestones, that would lead to a production model of a system that would be built in Phase II. In Phase II, devices suitable for near-commercial applications must be built and tested, and issues associated with manufacturing the units in large volumes at a competitive price must be addressed.

**Grant applications are sought in the following subtopics:**

**a. Reliable, Low-Cost, Self-Powered Wireless Sensors for Commercial Buildings**

Buildings use more energy than any other sector of the U.S. economy, consuming more than 70 percent of electricity and over 50 percent of natural gas. Investing in the development of new technologies for energy-efficient buildings yields:

- Cost savings for American homeowners and businesses;
- Reductions in peak demand, providing the energy needed for a strong economy with fewer new power plants; and
- Expeditious and sustained reductions in carbon dioxide emissions—with fast paybacks and positive economic returns.

Grant applications are sought for sensor technologies and systems that achieve reliability, low maintenance, and low cost through advancements in wireless technologies such as Surface Acoustic Wave (SAW) technologies and nano-sensors that self power partially or completely. Desired system requirements include the ability to 1) accommodate large networks of sensors with up to 5000 nodes 2) distinguish individual measurements despite heavy signal attenuation due to surroundings; 3) sample/record every two minutes or less; and 4) remote data exchange (e.g. cloud). Device requirements include: 1) Unit cost less than $20 including installation; 2) 5-year+ sensor life; 3) redundant sensors on each unit; 4) no/low (less than $2/year) cost maintenance; 5) Accuracy of +/- 3%; 6) Secure communication capability including authentication and encryption; 7) communication range of 500+ feet with capability to use data relay to circumvent typical interferences.

Questions – contact: Alan Schroeder, alan.schroeder@ee.doe.gov

**b. Technologies Related to Hybrid Electric Power-train Systems**

Electric drive vehicles such as hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and electric vehicles (EVs) have been identified as one important way to address the challenges of the nation’s dependence on imported oil and the need to reduce the emission of greenhouse gases. An important step toward vehicle electrification is large-scale manufacturing of electric drive vehicles that are cost competitive and provide similar safety with conventional vehicles. This subtopic seeks improvements to overcome critical barriers in electrochemical storage technologies and power inverters/converters.

Grant applicants are sought to develop electrochemical energy storage technologies which support commercialization of micro, mild, and full HEVs, PHEVs, and EVs. Some specific improvements which are of interest include: new low-cost materials; improvements in manufacturing processes, speed or yield; improved cell/pack design minimizing inactive material; significant improvement in specific energy (Wh/kg) or energy density (Wh/L); and improved safety.

When appropriate, evaluation of the technology should be performed 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). Phase I feasibility studies should 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. See references for DOE and USABC energy system goals and test procedures.

Power electronic inverters and converters are essential for electric drive vehicle operation, and currently add significant cost to these vehicles, therefore limiting their commercialization potential. Improvements in their performance can lead to cost reduction or better utilization of their capabilities in vehicles, as outlined in the U.S. DRIVE partnership Electrical and Electronics Technical Team Roadmap.

Grant applications are also sought to develop subcomponent-level improvements to power electronic inverters or converters which would support commercialization of micro, mild, and full HEVs, PHEVs, and EVs. Some specific improvements which are of interest include: small, lightweight low loss magnetic materials for passive inductors; low cost, high-temperature capable packaging materials for power semiconductor modules; improved direct-bond copper materials; and improved die attachment methods.

Proposals will be deemed non-responsive if the proposed technology is prohibitive to market penetration due to high cost; requires substantial infrastructure investments or industry standardization to be commercially viable; cannot accept high power recharge pulses from regenerative braking. Proposals deemed to be duplicative of research that is already in progress will not be funded; therefore all submissions should clearly explain how the proposed work differs from other work in the field. To be responsive, a proposal must define the relevant state-of-the-art (such as cost for a particular material) and clearly demonstrate that if successful the proposed research will result in significant improvements.

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

**c. Next Generation Processes for Carbonate Electrolytes for Battery Applications**

There is an urgent need to develop better manufacturing processes for Carbonate Electrolytes in the US. Recently, carbonates have become very important solvents in the emerging markets like lithium ion battery solutions and other electrochemical and coating sectors. In particular, Dimethyl Carbonate (DMC) has many advantages as a choice electrolyte solvent for lithium battery applications because it provides for a safe (low volatility and non-flammable) and long-lasting battery that can withstand existing voltage and high temperatures; has a long shelf life and offers a high mobility for the lithium ions; enhances the power density of the battery; and will lower the production cost of batteries.

DMC is strategically very important to the US battery markets, yet none of it is manufactured in the US. The global battery market is about US$50 billion, of which approximately $5.5 billion is captured by the rechargeable (secondary) batteries. The Freedonia Group, Inc. predicts a US demand of primary and secondary batteries of $US 18 billion by the year 2012. Batteries are everyday necessities, powering everything from tools to cars to remote controls. The carbonates, especially, DMC, are used as electrolyte solution for the lithium-ion based batteries. Currently, Asia, particularly China, monopolizes the production of DMC and there are no domestic U.S. manufacturers. DOE has interest in the energy efficient production of a highly strategic chemical like DMC that supports a growing market for hybrids and electric vehicles, which will in turn significantly reduce our dependence on foreign oil as well as correspondingly reduce greenhouse gas emissions.

Grant application are sought to develop improved manufacturing processes for DMS or any other carbonates that are simpler, more cost competitive and more energy efficient. Processes to manufacture such carbonates that use carbon dioxide as one of the feedstocks and therefore, serve as a productive use for CO2 are also welcome.

Questions – contact: Dickson Ozokwelu, Dickson.ozokwelu@ee.doe.gov

### d. Advanced Processing of Rare Earth Elements

In its first Critical Materials Strategy, DOE determined that several components of the clean energy technologies depend on materials at risk of supply disruptions in the short term. Five rare earth metals (dysprosium, neodymium, terbium, europium, and yttrium) were assessed as critical. International market distortions are currently causing limited supplies of rare earth materials and the manufacture of U.S. clean energy technologies are likely to be impacted by constrained supplies. As clean energy technologies are deployed more widely in the decades ahead, their share of global consumption of rare earths are likely to grow from 7% in 2010 to 20% or more by 2025, leading to supply shortages for clean energy technologies.

Grant applications are sought to develop new technologies and/or advanced processes to enable more rapid, flexible, energy-efficient, environmentally-friendly processing of rare earth elements. The end goal of these technologies/processes should be to increase the domestic supply of rare earth elements and/or decrease the costs of processing rare earth ores to high purity metals. Areas of research interest:

- Rare earths currently require multiple separation steps to yield high purity material. Decreasing the number of separation processes would significantly decrease the cost of the materials. Solvent extraction techniques which utilize green chemistry techniques while increasing separation factors are of interest. These separation techniques should be sufficiently flexible and scalable to be economically applied to recycle streams and other feedstocks.
- Minerals processing entails physical separation steps such as beneficiation, gravity concentration, flotation, and magnetic or electrostatic separation. These steps are particularly dependent upon the chemical makeup of the ore. Innovations in materials processing to eliminate steps in the process and allow for flexibility of the input stream are desired.

Currently, high purity metals are needed as starting materials for use in clean energy technology subcomponents such as magnets. To achieve metal form, the input stream is first purified to oxides, chlorides, or other intermediate pre-cursors. New processes to avoid these intermediates in the formation of relevant subcomponents are sought.

Questions – contact: Charles Russomanno, Charles.Russomanno@ee.doe.gov

### e. Distributed Production of Hydrogen from Waste Water

A key part of the DOE Fuel Cell Technologies' (FCT) Program Portfolio is Hydrogen Fuel R&D which focuses on materials research and technology development to address key challenges to hydrogen production, delivery, and storage; and to enable low cost, carbon-free hydrogen fuels from diverse renewable pathways. The production research efforts in this portfolio encompass small-scale hydrogen production up to large-scale centralized production. [1] The widespread use of hydrogen for transportation and stationary power will require cost effective and energy efficient hydrogen production and delivery technologies and pathways. Previous DOE R&D has focused on distributed hydrogen production at forecourt fueling stations (1,500 kg $H_2$/day production) and central hydrogen production from renewable resources (facilities producing >30,000 kg $H_2$/day) with promising results. [2] Small to medium scale distributed production of hydrogen from renewable resources has not received as much attention.

Grant applications are sought for technologies for hydrogen production at small to medium scale (e.g., 1-30 kg/day), applicable primarily for stationary fuel cells at commercial (e.g. small industrial plants or businesses) sites, but which could also potentially be applicable for home use or small forecourt stations. The primary inputs into the proposed technology should be a renewable energy resource (e.g., solar, wind, biological) as well as a water-based waste or slip-stream available at site-of -use of the proposed technology. The waste or slip-stream could include any form of potable or non-potable water (salt water, tap water, river water, etc.) or an effluent from an industrial, agricultural, or cleaning process. Example technologies could include, but are not limited to, microbial bio-reactors or electrolyzers, or direct solar-powered electrolysis. Proposed technologies must be scalable to at least 30 kg/day hydrogen production yield and the quality should meet SAE TIR J2719 specifications being developed with aid from the U.S. DOE Hydrogen Quality Working Group. [3]

Phase I must include an analysis identifying the technical, operational and maintenance, environmental, and safety requirements of the technology, estimates of energy use and emissions, a detailed analysis of the process economics for the proposed technology, and a preliminary design and technology development plan for achieving 30 kg/day hydrogen production with hydrogen quality meeting SAE TIR J2719 specifications. DOE's H2A Production spreadsheet tool [4] should be used to estimate the process economics. Requirement for off-board hydrogen storage, if any, should be identified but do not need to be included in the design and development plan.

Phase II would entail the construction of a proof-of-concept device to demonstrate that the technology developed in Phase I can meet yield and fuel quality specifications.

Questions – contact: Amy Manheim amy.manheim@ee.doe.gov

## f. Hydrogen Storage Technologies for Near-Term Fuel Cell Applications

The FCT Program maintains a comprehensive effort to overcome barriers for the widespread commercialization of hydrogen and fuel cell technologies [1]. The FCT Hydrogen Storage Program is seeking to develop and demonstrate hydrogen storage technologies that meet the performance and cost demands of several near-term markets that would benefit from operating with hydrogen and fuel cells including portable power, back-up power and material handling equipment, specifically those up to approximately 15 $kW_{net}$ power [2 - 5]. These applications have specific hydrogen storage performance requirements that may include but are not limited to: footprint; refueling time; run-time (capacity of stored energy); noise level; costs; and cycle-life. Other key performance requirements that should be defined for the specific application include: energy density (kg $H_2$/liter system); specific energy (kg $H_2$/kg system); operating temperatures; operating pressures; delivery temperature (min/max); delivery pressure (min/max); delivery rates and transient response time (e.g. 10% to 90% and 90% to 0% of maximum fuel delivery rate).

As an example, a comprehensive list of on-board storage system performance and cost targets for light-duty vehicle applications can be referenced at the DOE website [6]. However, light-duty vehicle applications are out of scope for this research request.

Grant applications are sought to identify, develop, and demonstrate hydrogen storage technologies that meet the application specific performance and cost requirements of a near-term application mentioned above. For portable power applications, the scope includes devices not permanently installed at a site, such as personal laptop battery rechargers, portable gensets or mobile lighting, with typical power outputs ranging from a few watts to a few kilowatts. For stationary power, the interest is focused on applications that are operated at a fixed location for back-up power such as telecommunications towers, emergency services and basic infrastructure (e.g., water and sewage pumps), where the typical power outputs range from 1 kW to 10 kW. Finally, for material handling equipment the scope is limited to applications that require output power ranging from 1 kW to 15 kW, such as for lift trucks, pallet jacks and airport baggage and pushback tractors.

In addition to the general requirements for Phase I, a technical gap analysis for the proposed hydrogen storage technology should be included, however Phase I should not include any material development or hardware construction/testing.

Questions – contact: Ned T. Stetson, Ned.Stetson@ee.doe.gov

## g. 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: Charles Russomanno, Charles.Russomanno@ee.doe.gov

**References**

**Subtopic a:**

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## 10. SELECTED RENEWABLE ENERGY TECHNOLOGIES

The U.S. Department of Energy is seeking the development of innovative technologies for: (a) Low-emission, high-efficiency biomass cook stoves; (b) Process intensification of biochemical and thermochemical conversion pathways for fuels and chemicals from biomass; (c) Innovative technologies (not conventional Rankine or Binary cycle) for electricity generation from geothermal heat and fluid resources; (d) Manufacturing tools for reliability testing in PV module manufacturing environments; (e) PV module and system manufacturing metrology, diagnostics, and process control; (f) Mooring Technologies for Floating Offshore Wind systems; and (g) Advanced electrical grid interfaces for Marine Devices.

Grant applications submitted in response to this topic must: (1) include a review of the state-of-the-art of the technology and application being targeted; (2) provide a detailed evaluation of the proposed technology and place it in the context of the current state-of-the-art in terms of performance, lifecycle cost, reliability, and/or other key attributes; (3) analyze the proposed technology development process, the pathway to commercialization, the large potential markets it will serve, and the attendant potential public benefits that would accrue; and (4) address the ease of implementation of the new technology.

Phase I should complete (1) a preliminary design, (2) a characterization of laboratory devices using the best measurements available, including a description of the measurement methods, and (3) the preparation of a road map with major milestones, that would lead to a production model of a system that would be built in Phase II. In Phase II, devices suitable for near-commercial applications must be built and tested, and issues associated with manufacturing the units in large volumes at a competitive price must be addressed.

**Grant applications are sought in the following subtopics:**

### a. Clean Biomass Cookstove Technologies

An estimated 2.5 billion people, or about one-third of the world's population, rely on biomass fuel for cooking. Improved cookstoves can increase access to clean energy, enhance indoor air quality, personal health, livelihoods, and the environment. Progress has been made in designing and disseminating cookstoves with reduced emissions and increased efficiency, but further reductions in emissions are needed to meet WHO guidelines for indoor air quality (IAQ), [1] to achieve significant health benefits, and to limit GHG emissions like black carbon.

As part of the U.S. government's commitment through the Global Alliance for Clean Cookstoves, DOE is interested in supporting research to develop low-emission, high-efficiency biomass cookstoves. The Alliance has set a goal of disseminating 100 million clean cookstoves by 2020 that provide significant health, energy, and climate benefits. To achieve this goal, these stoves must have significantly reduced emissions and higher efficiencies, they must address user preferences and needs, and they must be widely available and affordable.[2] To verify stove performance in the field, lower-cost, more user-friendly, and long-lasting data logging instruments with wireless capability have been identified as an important need.[3] Improved field performance data can also provide feedback for the stove development process. Small businesses developing cookstove technologies can drive innovation in the U.S. for international markets as well as domestic markets where the technologies are applicable. Work supported by an SBIR grant must be performed in the U.S., including all stages of R&D and demonstration—such as controlled cooking tests. DOE encourages applicants to separately engage in field studies to assess actual user needs and performance in regions identified as being of interest for the stove to be ultimately deployed.

Grant applications are sought for the development of innovative affordable biomass cookstoves that reduce emissions by at least 90% and reduce fuel use by at least 50% compared to traditional biomass-fueled cookstoves and open fires used in many areas of developing countries. This level of performance should be robust under a wide range of fuel and operating conditions. Controls, sensors, and/or fans that lead to significant performance improvements and/or cost reductions also fall under this area.[3] Proposed technologies should address the conditions, use the biomass fuels, and meet the cooking needs of the people in geographical areas in which the stoves will be ultimately deployed. All stages of research and product design should be integrated with laboratory and controlled cooking tests in the U.S. for validation of stove performance,[4, 5] usability and ease of maintenance. By the end of Phase I, projects should benchmark the performance of existing technologies, establish user preferences and needs, and demonstrate that prototype designs can reduce emissions by at least 90% and fuel use by at least 50% from existing technologies in laboratory studies. During Phase II, projects should improve stove design to increase performance and usability and reduce costs to a level that is affordable by households in geographic regions of interest.

Grant applications are also sought for instruments to improve field testing and monitoring of stove performance and usage. Instruments should be affordable, reliable, durable, and user-friendly, while providing real-time measurements of stove use, efficiency, emissions, and/or exposures. By the end of Phase I, projects should have evaluated the feasibility of the monitoring technology. During Phase II, projects should evaluate and validate the reliability and accuracy of the monitoring technology and develop analysis methods and software to facilitate the widespread use of the technology in the regions of interest.

Questions – contact: Travis Tempel, Travis.Tempel@ee.doe.gov

## b. Process Intensification of Biochemical and Thermochemical Conversion Pathways for Fuels and Chemicals

One of the barriers to broad deployment of biochemical and thermochemical conversion pathways for biomass utilization for fuels and chemicals is the number of unit operations and the overall process complexity required to produce a final product from biomass. These have a direct effect on the capital cost of a production facility and the operation costs associated with producing biofuels and bioproducts from biomass. Process intensification involves a reduction in the size or number of process units needed to handle a given volume of feed / product. Approaches are to decrease mass- and heat-transfer resistance by means such as: intense mixing (without excessive pressure-loss penalty) to create chemical processes that are cleaner, smaller, safer, faster, cheaper, and more efficient; reduction of length scales for heat transfer & diffusion (e.g., micro-channel reactors); external-field-driven phase separation (HiGee, cyclones, electromagnetism, etc.); and the design of chemical processes that reduce or eliminate the use and generation of hazardous substances in an energy efficient manner.

Process intensification also refers to combining one or more unit operations into a single operation; examples are extractive fermentation, reactive distillation and catalytic pyrolysis. Process intensification methods are needed that exploit reaction engineering principles such as in situ separation (including but not limited to membrane-based approaches) to remove inhibitory components or products (e.g., alcohols, acids, salts) and thereby facilitate maintenance of higher reaction rates and attainment of high reaction yields. Potential approaches include advanced concepts such as reactive separation schemes that will enable in situ combination with bio/catalysis steps, or approaches that are substantially more energy efficient and/or require much less capital equipment.

Grant applications are sought that will focus on process intensification in the biochemical and thermochemical conversion pathways to (a) reduce the size or improve the efficiency of unit operations and/or (b) reduce the number of unit operations, with the goal of significantly reducing plant capital and operating costs associated with the production of biofuels and bioproducts. A “significant reduction” in plant capital cost is considered to be a reduction of $1 or more in the unit cost per annual gallon of production capacity compared to the design case (e.g. a reduction from $10/gallon of installed capacity to $9/gal). A “significant reduction” in plant operating costs is considered to be a reduction of $0.25 or more in the production cost per gallon of product (e.g. a reduction from $3.50/gallon of installed capacity to $3.25/gal).

Questions – contact: Brian Duff, Brian.Duff@ee.doe.gov

### c. Innovative Technologies for Electricity Generation from Geothermal Heat and Fluid Resources

Geothermal resources have an enormous, but largely untapped, energy resource.[1] Grant applications are sought to develop innovative methods of producing electricity from geothermal heat and fluid resources. Technologies and methods that can serve as an alternative to Rankine cycle or conventional binary power plants are the main area of interest for this announcement.[2] The actual power conversion system (which transforms energy contained in the geothermal resource into electricity), is the focus of this subtopic; specifically, technologies that will utilize the heat content, fluid pressure, fluid properties (e.g. salinity), multi-phasic nature of the fluid stream etc. of a geothermal resource to produce electricity.[3] Applications proposing to examine working fluids or mixtures of working fluids to be utilized in Rankine Cycle plants will not be considered. Applications seeking the modification of and/or addition to existing Rankine or Binary cycle technology will not be considered. Proposed technologies or methods should offer advantages over existing commercial technologies in areas of efficiency, capital costs, operating costs, maintenance costs, and other key performance factors.

Questions – contact: Greg Stillman, Greg.Stillman@ee.doe.gov

### d. Manufacturing Plant Tools for Reliability Testing in Photovoltaic System Components or Subcomponents

Solar energy is our largest energy resource and can provide clean, sustainable energy supplies, including electricity, fuels, and thermal energy. However, the cost-effective capture of the enormous solar resource is problematic and cost reductions during the manufacturing process, including quality control, are required.

Grant applications are sought for the development of tools that can be used to conduct reliability testing in PV manufacturing environments. New tools are needed for the testing of components (e.g., modules, inverters) or subcomponents (e.g., cells, micro-inverters, individual layers of a module), and should combine high performance, low cost, and a small floor footprint.

Questions – contact: Jim Kern, James.Kern@ee.doe.gov

### e. Photovoltaic Module and System Manufacturing Metrology, Diagnostics, and Process Control

The rapid scale-up of the manufacturing of photovoltaics, particularly thin-film systems, is challenging the ability of conventional techniques to make real-time non-destructive measurements of material characteristics in high-volume, high-production-rate environments and then use this information to implement real-time process control of the manufacturing process.

Grant applications are sought for the development of novel, advanced, real-time nondestructive materials characterization tools for use in metrology, diagnostics, and process control of high-volume manufacturing lines for photovoltaic systems.

Questions – contact: Jim Kern, James.Kern@ee.doe.gov

### f. Mooring Technology for Floating Offshore Wind

Offshore wind mooring systems, including anchors, tendons and tendon connections, as well as mooring system installation are all significant cost drivers for tension-leg offshore wind platforms and spars. A new generation of vertical-load anchors or other novel concepts that are capable of handling the high loads found in tension-legs, that are adaptable to the variety of depths and seabed conditions found in an offshore wind farm, and that can be economically manufactured and deployed could lower survey, design, and installation costs. New pipe, wire, and synthetic rope tendon designs, connection methods and installation techniques can additionally help to lower floating wind farm total costs.

Grant applications are sought for new technologies that can provide low-cost, easily deployable mooring systems for floating offshore wind systems employing tension-leg platforms (TLPs) and tension-leg spars. Grant applications must: (1) demonstrate that the new proposed technology would allow for easily deployable, versatile, robust mooring systems for floating, tension-leg offshore wind platforms, and spars; and (2) demonstrate clear economic and technical advantages over the existing state of the art.

Questions – contact: Cash Fitzpatrick, Cash.Fitzpatrick@ee.doe.gov

## g. Advanced Electrical Grid Interface for Marine Devices

Deployment and electrical component costs can drive the cost of commercial marine energy installations. Currently, many marine energy designs incorporate existing, land-based designs and processes for the collection, conversion, and transmission of electricity from marine deployed electrical generators to land based grid interfaces. Significant improvement in efficiency and cost may be attainable by designing grid interfaces explicitly for use in marine energy devices.

Grant applications are sought for the development of innovative systems and components that improve the collection and transmission of electricity from marine energy device generators to land based electrical interfaces. The objective of these device and array electrical subsystems is to advance widespread deployment of marine energy systems through reduced equipment, deployment, and lifecycle costs (through reduced operations and maintenance costs and/or increased performance). Cost reduction pathways directed towards marine-designed electrical equipment or grid connection methods must improve cost and performance of electrical subsystems, including wet mate connectors and advanced umbilicals for marine energy devices and arrays.

Questions – contact: Charlton Clark, Charlton.Clark@ee.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: Sam Baldwin, Sam.Baldwin@ee.doe.gov

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## PROGRAM AREA OVERVIEW: OFFICE OF ENVIRONMENTAL MANAGEMENT

With the end of the Cold War, the Department of Energy (DOE) is focusing on understanding and eliminating the enormous environmental problems created by the Department's historical mission of nuclear weapons production. The DOE's Office of Environmental Management (EM) seeks to eliminate these threats to human health and the environment, as well as to prevent pollution from on-going activities. The goals for waste management and environmental remediation include meeting regulatory compliance agreements, reducing the cost and risk associated with waste treatment and disposal, and expediently deploying technologies to accomplish these activities. While radioactive contaminants are the prime concern, hazardous metals and organics, as defined by the Resource Conservation and Recovery Act (RCRA), are also important.

DOE has approximately 91 million gallons of liquid waste stored in underground tanks and approximately 4,000 cubic meters of solid waste derived from the liquids stored in bins. The current DOE estimated cost for retrieval, treatment and disposal of this waste exceeds $50 billion to be spent over several decades. The highly radioactive portion of this waste, located at the Office of River Protection (Hanford Reservation), Idaho, and Savannah River sites, must be treated and immobilized, and prepared for shipment to a future waste repository.

DOE also manages some of the largest groundwater and soil contamination problems and subsequent cleanup in the world. This includes the remediation of 40 million cubic meters of contaminated soil and debris contaminated with radionuclides, metals, and organics [1]. The Office of Groundwater and Soil Remediation focuses on four areas of applied research including the Attenuation-Based Remedies for the Subsurface Applied Field Research Initiative (Savannah River Site), the Deep Vadose Zone Applied Field Research Initiative (Hanford Site), the Remediation of Mercury and Industrial Contaminants Applied Field Research Initiative (Oak Ridge Site), and Advanced Simulation Capability for Environmental Management. The following topic solicits grant applications to develop technologies for characterizing tank wastes, nuclear materials and disposition, deactivation & decommissioning. The subtopics provide more detailed descriptions of specific needs.

For additional information regarding the Office of Environmental Management priorities, please visit us on the web at http://www.em.doe.gov.

### 11. SPENT NUCLEAR FUEL STORAGE

During the last 60 years, a variety of sources within the Department of Energy (DOE) and its predecessors generated spent nuclear fuel (SNF). In addition to being used to generate commercial electricity, nuclear reactors are used in government-sponsored research and development programs, universities, and industry; in science and engineering experimental programs; at nuclear weapons production facilities; and by the U.S. Navy and military services. The operation of these nuclear reactors results in spent nuclear fuel. DOE has an inventory containing a broad range of fuel types; materials of construction, sizes, shapes, enrichments and physical conditions in a variety of storage systems. In the past, DOE reprocessed SNF to recover fissile materials and other valuable nuclides for national defense or research and development programs. In 1992, the decision was made to phase out reprocessing, leaving a backlog of unprocessed fuels stored in pools and in a variety of dry storage systems.

In the early 1980s, DOE formally adopted a national strategy to develop mined geologic repositories as disposal facilities for spent fuel and high-level radioactive waste. In 1983, the DOE identified nine potentially acceptable sites and, in 1984, selected three sites as candidates for further characterization. In 1987, Congress directed DOE to pursue the investigation of only the Yucca Mountain, Nevada, site in order to determine whether the site was suitable for development as a repository. On June 3, 2008, DOE submitted a License Application to the Nuclear Regulatory Commission (NRC) for construction of a High-Level Waste Repository at Yucca Mountain, Nevada. On March 3, 2010, DOE submitted a motion to withdraw the pending license application for the permanent geologic repository to the NRC Atomic Safety and Licensing Board. Additional motions have been filed in federal court by stakeholders. While the nation wrestles with this issue, a decision to direct the disposition or disposal of SNF is delayed. Until a disposal or long-term storage facility is operational, the apparent default position for most spent fuel is to maintain the fuel in existing storage.

While DOE has not made a decision to extend the use of existing fuel storage facilities, it is prudent to evaluate the risk associated with continued use of existing storage. DOE needs the capability for non-destructive examination and evaluation of existing storage facilities, safety systems and components (e.g. fuel canisters, baskets, storage racks) to ensure the function provided by the original design is maintained.

**Grant applications are sought in the following subtopics:**

### a. Develop Advanced Techniques to Characterize Material Aging Conditions to Extend the Life of Several Spent Nuclear Fuel (SNF) Dry Storage Facilities

Research should be pursued to develop advanced techniques to characterize material aging conditions to extend the life of several SNF dry storage facilities. The DOE complex has numerous storage facilities that need to be characterized and their design lives extended for longer term nuclear fuel storage. DOE is interested in remote monitoring of conditions of materials in high radiation environments. An immediate need exists for equipment and analytical tools that are capable of operating remotely in a high radiation environment that can provide characterization of existing storage components with sufficient resolution to plan replacement, repair, or other corrective action. DOE must be able to rely on the data acquired to validate that the features important to nuclear safety have maintained the required functional and operational capabilities. Corrosion of metal component is of particular interest.

The ability to operate for extended periods in high radiation environments is desirable because minimum contact with workers will be possible once the instrument is deployed in the contaminated facility. An essential requirement is that the equipment be sufficiently small so that it can be readily deployed through existing access points and operated remotely in normally inaccessible areas of the SNF dry storage facilities.

Technology is sought and should include development and proof of application of remote visual and/or electromagnetic acoustic transmission (EMAT) technology to significantly enhance the corrosion monitoring capabilities of aging SNF storage equipment and structures and facilitate the safe and cost-effective life extension of SNF storage facilities.

As part of the Idaho National Laboratory (INL) Idaho Cleanup Project, the EM Program must maintain SNF inventories in dry storage facilities located in Idaho and Colorado. Some of these facilities [Fort St. Vrain (FSV) and Three Mile Island, Unit 2 (TMI-2) Independent Spent Fuel Storage Installations (ISFSIs)] are licensed by the NRC, while others [Underground Fuel Storage Facility (UGFSF) and Irradiated Fuel Storage Facility (IFSF)] are operated solely under DOE regulation. In either case, some of the SNF storage systems have exceeded their original design lives, or in the case of the NRC-licensed facilities, will either need to have a license extended beyond the original design life of the facility, or need to honor commitments made to the NRC for post-license renewal inspections.

Carbon steel corrosion can be induced on the interior surfaces of the loaded Fuel Storage Containers (FSC) at the FSV ISFSI due to moisture and tritium generation. Remote internal inspection of loaded FSCs is necessary to characterize any unanticipated degradation through longer term storage. A limited scope examination of the FSC vault at the FSV ISFSI was performed in 2008 as part of a facility aging management review to support development of the FSV ISFSI license renewal application. Subsequent to renewal of the NRC license in June 2011, DOE-ID agreed to a new license commitment to perform a more comprehensive examination of normally inaccessible areas of the storage vaults to detect unanticipated degradation of components important to safety. This is an ongoing license commitment for the duration of the extended 20-year license. Collaborative remote examination technology development and demonstration can be performed with the Public Agency for Radioactive Waste Management (PURAM) of the Republic of Hungary though the Memorandum of Understanding established between DOE and PURAM in 2009.

Recently issued NUREG-1927 requires, as part of the ongoing TMI-2 ISFSI license renewal effort, examination of storage module and canister areas that are not normally accessible or observable. Evaluation of aging conditions, such as carbon steel corrosion in the vented Dry Storage Canisters and concrete degradation inside the Horizontal Storage Modules of the TMI-2 ISFSI, will need to begin no later than 2012 to support development and submittal of a NUREG-1927 compliant license renewal application by 2017. Each licensee relies on the precedent established by the previous licensee's work with the NRC to develop a technical position for extension. Due to the new guidance and lack of data from examination of areas not normally assessable, the commercial industry using dry fuel storage systems will benefit from work performed under this task.

The UGFSF and IFSF in Idaho have been in operation since the early 1970s. Fuel storage containers stored within these facilities have been in use much longer in many cases. The long-range SNF disposition plan is to have the SNF removed from Idaho no later than 2035, but recent developments revolving around repository availability suggests that the operational life for these facilities may likely exceed 60 years. The decision to withdraw the NRC license application for the Yucca Mountain geologic repository will significantly delay retrieval of SNF from these aging facilities, well beyond the original design criteria for the facilities and containers in some cases. Aging conditions of the facilities and safety structures, systems, and components need to be assessed to support extended SNF dry storage.

While the EMAT technology is of great interest to the program, all ideas are sought.

Questions – contact: Latrincy Whitehurst**,** latrincy.whitehurst@em.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: Latrincy Whitehurst**,** latrincy.whitehurst@em.doe.gov

**References**

**Subtopic a:**


1. DOE. 2008. *Engineering and Technology Roadmap: Reducing Technical Risk and Uncertainty in the EM Program*. Office of Environmental Management, U.S. Department of Energy. March 2008. http://www.em.doe.gov/pdfs/FINAL%20ET%20Roadmap%20_3-5-08_.pdf.
2. Final Report (**NUREG-1927**) - Nuclear Regulatory Commission *Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance* www.nrc.gov/reading-rm/doc-collections/**nuregs**/staff/sr**1927**/.
4. General Accountability Office. March 2011. *DOE NUCLEAR WASTE Better Information Needed on Waste Storage at DOE Sites as a Result of Yucca Mountain Shutdown* http://www.gao.gov/new.items/d11230.pdf.


# 12. DEACTIVATION AND DECOMMISSIONING

The U.S. Department of Energy (DOE) Office of Environmental Management (EM) infrastructure encompasses over 3000 facilities, including over 1000 nuclear and radioactive buildings. These facilities account for close to 25 percent of the DOE's total buildings and other structures, and nearly 47 percent of the DOE's replacement plant value. The cost of Deactivation and Decommissioning (D&D) of the current and future "surplus" facilities in the EM complex is conservatively estimated at $32 billion and represents the second highest cost center within the EM Program.

The common perception is that the D&D of these facilities can be accomplished using existing commercially available technologies with few needs for innovative technologies/approaches. However, the portfolio of EM facilities awaiting D&D includes nuclear production reactors, test and research reactors, gaseous diffusion plants, chemical processing plants, fuel and weapons component fabrication facilities, radionuclide separations facilities, laboratories, thousands of miles of above ground, embedded, and buried pipelines, and a myriad of other contaminated facilities, process systems, and equipment. In short, the current EM facility D&D program encounters some unique challenges:

- Many facilities are over 50 years old and, over time, have continued to degrade and become “structurally unsafe” for personnel entry;
- Many contain a significant amount of contaminants and radioactive holdup (curies) that represent a source term for potential air, soil and surface/ground water contamination;
- Many of the facilities to be decommissioned are one-of-a-kind and/or unique to DOE with unprecedented scope and complexity and, in many instances, effective technologies are yet to be developed or will require significant re-engineering to meet DOE needs.

Therefore, with judicial inclusion and deployment of innovative approaches/technologies to resolve these unique challenges, the EM facilities D&D projects can be conducted in a more cost effective manner while achieving an enhanced worker safety and improved operational schedules. A brief and high level description of several technical needs of the current EM D&D program follows:

- Reduce risks to workers from potential exposures associated with deactivation and decommissioning activities - Workers are required to wear Personnel Protective Equipment/Personnel Protective Clothing (PPE/PPC) to protect them from exposure to hazardous contaminants, such as radionuclides, metals such as mercury, lead, asbestos, and organics. The DOE is interested in new or improved PPE and/or PPC that is protective against hazardous contaminants, ionizing radiation, is waterproof, lightweight and with improved “breathability” to reduce overheating and heat stress.

Detect and identify hazardous and radioactive contaminants in complex process piping components and systems - Process piping used in the production of nuclear materials contains residual radionuclides/hazardous materials and the accumulation of corrosion products on the interior pipe walls entraps this contamination. Additionally, the subsurface of the interior pipe walls can be activated due to the exposure or absorption of radioactive materials. Detecting and identifying the radionuclide particles is a prerequisite to prepare the piping system components for proper disposal in accordance with federal, state, and local regulations.

Decontaminate and properly dispose of hundreds of miles of radioactive contaminated piping resulting from site remediation and D&D activities - In particular, the DOE is interested in the development of technology to disassemble (“shred”) contaminated piping and systems and to separate metallic and non-metallic materials, while ensuring the protection of workers and the environment.

Dismantle and size-reduce radioactive contaminated, hardened structures with minimal spread of radiological contaminated material - Often concrete structures are required to be demolished that may be located in geometric confined area. Cutting and dismantling of contaminated high strength metal structures often present similar technical challenges in the D&D of EM facilities. Therefore, compact demolition equipment capable of removing high density/high strength concrete that can be used in a geometric confined area combined with cold cutting/laser cutting technologies will allow the DOE decommissioning team to perform facility/equipment disassembly in safer and more efficient manner with reduced production of secondary waste stream.

Autonomous or remotely operated characterization and surveillance system/platform capable of entering and operating in unsafe structures, highly hazardous and radioactive conditions – Multiple EM facilities to be decommissioned are highly contaminated and/or structurally unsound. Entry by workers to conduct characterization is therefore hazardous from radiological/chemical exposure or from structural failures. The developed characterization/surveillance tools must be able to perform quantitative or semi-quantitative analyses of materials inside these facilities for extended periods of time and requiring minimum physical contact or maintenance by D&D workers.

**Grant applications are sought in the following subtopics:**

**a. Develop a Technology for Segregation of Mercury Contaminated Debris**

There will be over 1 million cubic feet of mercury contaminated debris resulting from the D&D of facilities at the Oak Ridge Y-12 site. To assume all of the debris is contaminated at >260mg/kg and treat and dispose accordingly would be extremely costly and time prohibitive. Therefore, a technology is needed to efficiently and effectively characterize and segregate D&D debris (wood, cinder block, bricks, concrete) requiring treatment to meet applicable regulatory requirements. The properties and behaviors of mercury in the heterogeneous matrix can be utilized to separate the mercury and/or contaminated debris requiring treatment from the bulk and stabilize it in the matrix to meet the Occupational Safety and Health Administration's enforceable regulations for air and skin exposures pathways ( 29CFR1910.1000) plus proper disposal of the Low Mercury Subcategory (<260 mg/kg) and Universal Treatment Standards (0.025 mg/L )as measured by the Toxicity Characteristic Leaching Procedure.

Questions – contact: Paula Kirk, paula.kirk@em.doe.gov

**b. Develop Fiber Optic Sensors to Detect Ionizing Radiation and Identify the Type of Radionuclide Contamination**

D&D of nuclear facilities requires that radioactive and hazardous materials be identified prior to the onset of the decommissioning process and monitored during the entire deactivation and dismantling processes. The ability to identify radioactive/hazardous material contamination levels and locations is essential to accurately evaluate and establish the decommissioning project's baseline as well as protecting personnel performing deactivation activities.

Research should be pursued to develop a fiber optic sensor device that can detect and measure the ionizing energy produced by radionuclide formed from residual deposits in process piping systems. In particular, process piping used in the production of nuclear materials contains residual radionuclide that must be removed during the facility decommissioning process. The accumulation of corrosion products on the interior pipe walls entraps radioactive particles and is often difficult to measure. The residual radioactive contamination must be accurately evaluated to establish the decommissioning and disposal project's scope, cost, and schedule requirements. The final system should contain signal processing components that can identify the specific radionuclides of the residual deposits and quantify the concentration of the radioactive materials in the pipes. The fiber optic sensor device should be capable of operating in steel and stainless steel pipe & tubing ranging from 6 inches to ¼ inches nominal pipe diameter. Often corrosion deposits and films are encountered on the inside pipe wall surfaces which entrap radioactive particles, therefore, the fiber optic sensor system must be able to detect and measure radionuclide in this type of environment.

Questions – contact: George Cava, george.cava@em.doe.gov

### c. Develop a Characterization Technology for Closed Systems

The risks and dangers associated with breaching closed systems, such as a pipe or piece of equipment, without knowing what chemical or radiological hazards are in that system have been experienced during DOE D&D operations. Punctures can release noxious gases or caustic liquids; a spark or sudden oxidation can ignite pyrophoric material; physical contact can detonate shock sensitive material; and changes in configurations of enriched material can cause criticality. Where multiple radionuclides are present in a closed system, certain energy peaks can be masked or hidden leading to erroneous assumptions in developing the safety basis and waste handling plans. The development of a sensitive and accurate non-invasive (or minimally invasive) characterization technology to detect, locate, characterize, and quantify hold up in closed systems is needed to improve the safety and efficiency of D&D operations.

Questions – contact: Paula Kirk, paula.kirk@em.doe.gov

### d. Develop Nano-Sensors to Detect and Identify Radionuclide and Hazardous Material Contamination

D&D of nuclear facilities requires that radioactive and hazardous materials be identified prior to the start of work and monitored during entire D&D period. The ability to identify radioactive/hazardous material contamination levels and locations is essential to accurately evaluate and establish the project's baseline as well as protecting personnel performing work. Therefore, a precise method to detect and measure residual radionuclide is beneficial to performing decommissioning activities safely and maintaining the project within cost and on schedule.

Research should be pursued to develop a nano-sensor array that can detect and measure the ionizing radiation and hazardous substances such as Volatile Organic Compounds (VOC). The source of the beta/gamma radiation is from radionuclide residual deposits resulting from the enrichment of Uranium and the production of Plutonium. The radionuclides of current interest are:

| Isotope | Decay Mode | Decay Energy, MeV | Specific Activity, Ci/g |
|---|---|---|---|
| Tc99 | beta | 0.292 | 1.7EE -2 |
| U234 | alpha | 4.856 | 6.19EE -3 |
| U235 | alpha | 4.681 | 2.1EE -6 |
| U238 | alpha | 4.268 | 3.3EE -1 |
| K40 | beta | 1.5 | 8.4 EE -9 |
| Th234 | beta/gamma | 0.192 | 2.32 EE -4 |

The nano-sensor array system should transmit a wireless signal of the detected hazard to remote processing components which can identify the location and quantify the hazard encountered.

The nano-sensor array device should be designed to be deployed on a robotic platform or worn as part of Personal Protective Clothing (PPC). Additionally, the nano-sensor array components should be robust to allow decontamination and reuse, thereby minimizing the waste generated during nuclear decommissioning activities. When incorporated with PPCs, the nano-sensor array system should provide a feedback and/or alert signal to the user of the hazard that is detected.

Questions – contact: George Cava, george.cava@em.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: Latrincy Whitehurst, latrincy.whitehurst@em.doe.gov

**References**

**Subtopics a-d:**


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3. Past research in the area of D&D and technologies are available at http://www.em.doe.gov/EM20Pages/LegacyTechInformation.aspx.
4. http://www.sensorsmag.com/sensors/machine-vision/an-introduction-fiber-optic-sensors-1075.


## 13. RADIOACTIVE TANK WASTE TREATMENT

Radioactive tank waste is the most significant environmental, safety, and health threat in the Department of Energy (DOE) and is the largest cost element for the Office of Environmental Management (EM). At Hanford, the Office of River Protection's (ORP) efforts are focused on completing the safe retrieval, transport, vitrification, and disposal of the 53 million gallons of chemically hazardous and highly radioactive wastes that are currently stored in 177 large underground tanks. The Savannah River Site (SRS) has 51 underground waste storage tanks containing 36 million gallons of hazardous and radioactive waste. A significant portion of this waste is highly viscous sludge containing multiple indeterminate chemical compounds. The highly viscous nature of some tank waste promotes pipeline plugging while the multiple indeterminate compounds may inhibit the treatment processes.

Ensuring that tank waste sludges can be transported in pipelines without clogging or that clogs can be expeditiously removed will accelerate pipeline transfers by reducing operational conservatism (allowing for higher solids concentrations) and decrease the potential for transfer line plugging. In addition, radioactive tank waste treatment operations are highly complex, multi-phase processes. Numerous sampling points and millions of dollars per year at each site are required to analyze the samples for the plethora of data required from operational and closure requirements. The samples are difficult to obtain and are typically intensely radioactive. In-situ characterization technologies are needed to assist process operations such as retrieval (in-line), screening situations for process understanding (in-situ) and closure operations to determine extend of cleaning.

**Grant applications are sought in the following subtopics:**

### a. Prevention and Elimination of Plugging During the Transport of Sludges

Develop technologies to prevent, mitigate, and remove pipeline plugging to facilitate transfers of shear-thickening (non-Newtonian) sludges.

Routine tank farm operations such as waste feed delivery, Single Shell Tank (SST) retrieval, and evaporator operations require the transfer of slurries containing high specific gravity solutions with high solids content. In some cases, these slurries have plugged lines leading to schedule delays. The nature of radiological tank waste slurries within the DOE is complex and includes a harsh chemical (acidic), physical (particle-laden), and radiological environment. These sludges can form flocculated networks that could plug transfer lines. This behavior is especially likely when phosphate-bearing wastes streams are mixed. Pipeline plugging has the potential to negatively impact the performance of the retrieval effort. Technologies to prevent plugging will accelerate pipeline transfers by reducing operational conservatism (allowing for higher solids concentrations) in some cases and in other cases decreasing the potential for transfer line plugging.

In addition to technologies for preventing plugs, technologies are also being sought to remove plugs that may form or already exist in transfer pipes. The candidate technology may use robots or other mechanical devices to drill, bore, etch, etc. to remove the plug, but must cause minimal damage to the piping. The device must be able to negotiate elbows, fittings and other obstructions typical of piping systems. The transfer line may extend for several thousand feet.

Questions – contact: Latrincy Whitehurst, latrincy.whitehurst@em.doe.gov

### b. Novel In-Situ and Real-Time Analytical Techniques

The retrieval and treatment of high level tank wastes at Hanford and SRS are tremendously challenging, highly complex and require extensive characterization data throughout the process. Successful operation requires numerous sampling points and millions of dollars per year at each site to analyze the samples for the data required from operational and closure requirements. The samples are generally difficult to obtain and intensely radioactive. In many cases, the sampling involves robotic application to be developed for obtaining a single sample. In-situ and real-time characterization technologies are needed for:

- Retrieval of the waste from the tanks;
- Characterizing the tank heels for the constituents of concern to assist closure operations by determining the extent of cleaning; and
- Waste feed preparation/delivery for processing in the treatment plant.

Literally, tens of thousands of samples will require detailed analyses of chemical, physical and radiological properties until the waste tanks at Hanford and SRS are finally closed. In-situ characterization technologies may reduce sample loads while increasing data quality and allow real-time adjustments to be made to processing conditions. The National Research Council has recommended that DOE develop innovative methods to achieve real-time and, when practical, in-situ chemical, physical and radiological characterization of high-level wastes at all phases of processing (NRC 2010).

Questions – contact: Latrincy Whitehurst, latrincy.whitehurst@em.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: Latrincy Whitehurst, latrincy.whitehurst@em.doe.gov

**References**

**Subtopics a-b:**


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3. DOE, 2008, "Engineering and Technology Roadmap: Reducing Technical Risk and Uncertainty in the EM Program", Office of Environmental Management, US Department of Energy, March 2008. http://www.em.doe.gov/pdfs/FINAL%20ET%20Roadmap%20_3-5-08_.pdf
4. National Research Council, 2006, "Tank Waste Retrieval, Processing and On-Site Disposal at Three Department of Energy Sites", National Academies Press. ISBN-10: 0-309-10170-0 http://www.nap.edu/catalog.php?record_id=11618

## PROGRAM AREA OVERVIEW – OFFICE OF FOSSIL ENERGY

Fossil fuels are projected to remain the mainstay of 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, the DOE's Office of Fossil Energy (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 environmentally sound and economically competitive.

Particular attention will be focused on finding new ways to extract the power from coal – America's largest domestic energy resource – while simultaneously expanding environmental protection and confronting the issue of global climate change. Key R&D programs include: 1) developments in advanced research including materials, sensors, monitors, controls, biotechnology, computational processes, and new concepts that will be needed for these technologies to be commercially competitive; 2) developments in advanced gasification technologies including gas separation membranes, gas cleanup, improved gasification technologies; 3) clean fuels including hydrogen, synthetic natural gas, and ultra clean solid and liquid fuels from coal as well as mixed biomass and coal feedstocks which can result in neutral or negative carbon emissions, having a beneficial effect on climate change; 4) pollution control innovations for existing power plants including post-combustion $CO_2$ capture, compression, and beneficial uses and oxy-combustion technology); 5) carbon sequestration technologies that can capture, separate, transport, reuse, and permanently store greenhouse gases; 6) improved turbines for future coal-based combined cycle plants; and 7) development of stationary power fuel cells for coal-based central generation power applications. In addition, improvements in our ability to recover oil, natural gas, and methane hydrates are needed. Approximately two-thirds of our national petroleum reserve is "unrecoverable"; it cannot be extracted economically by conventional means. This unused resource could play a major role in supplementing the national petroleum supply if efficient approaches were developed for improved extraction. Natural gas production and utilization could also be increased through improved characterization of reserves and through better infrastructure. The most plentiful supplies of natural gas throughout the world may be the methane molecules trapped in ice-like structures called hydrates. Therefore, FE supports research to help unlock the mysteries of hydrates and develop future ways to tap their massive energy potential.

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

### 14. CROSSCUTTING FOSSIL ENERGY RESEARCH

The Crosscutting Research Program (formerly, Advanced Research program) within NETL's Office of Coal and Power R&D fosters the development of innovative, cost-effective technologies for improving the efficiency and environmental performance of advanced coal and power systems. In addition, Crosscutting Research (CCR) bridges the gap between fundamental research into technology alternatives and applied research aimed at scale-up, deployment, and commercialization of the most promising technologies identified. The CCR program encompasses three major subprograms: Sensors and Controls Innovations; High Performance Materials; and Computational Energy Sciences.

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from the Nation's most abundant and lowest cost resource, coal. Maintaining low-cost energy in the face of growing demand and increasing environmental pressures requires new technologies that will enable higher efficiency. The implementation of sensors and advanced controls in power systems can provide valuable methods to improve operational efficiency, reduce emissions, and lower operating costs. These sensors and controls must provide reliable and consistent data, longevity of use, and ease of calibration. However, it has been a challenge to develop sensors and controls that are able to endure the harsh environments associated with advanced power systems. This environment includes high temperatures (800-1500°C), high pressures (500-1000 psi), and corrosion due to abrasive materials.

High performance materials research cuts across many scientific and technological disciplines to address materials requirements for all fossil energy systems, including innovative advanced power systems. The goal is to bridge the gap between basic and applied research, often by pursuing "breakthrough" concepts based on mechanistic understanding from any discipline to develop materials with unique thermal, chemical, and mechanical capabilities.

**Grant applications are sought in the following subtopics:**

**a. High Temperature, Selective Gas Sensor Functional Materials for Fossil Energy Power Systems**

Novel sensor technologies are required for improved process control in existing fossil energy systems and to enable wide-spread implementation of advanced fossil energy technologies including coal gasification, turbines, and coal-fired boiler systems. Regardless of the specific sensor platform (chemiresistive, optical, surface acoustic wave, etc.), a functional sensor material often plays the crucial role of converting changes in gas species, temperature, and pressure into measurable signals. The ultimate performance of the sensor (sensitivity, stability, response time, and selectivity) is limited by the performance of the functional sensor material and novel material design concepts can be leveraged across a wide range of sensor platform technologies. The fastest response times and highest sensitivities are typically achieved through thin film based approaches. Thin film functional sensor materials suitable for advanced fossil energy applications must be stable at high temperatures under highly oxidizing and/or reducing conditions and in the presence of corrosive species such as $H_2S$. For gas sensing, selectivity is also critically important because of the numerous chemical species present in coal-based syngas. Functional sensor materials suitable for operating at maximum temperatures of 500°C are of interest for down-stream process monitoring but higher temperature functional sensor materials (500°C-1600°C) are an enabling technology for in-situ embedded sensors placed at the most demanding, highest value locations.

Metal oxide based thin films such as $SnO_2$, $TiO_2$, ZnO, $Ga_2O_3$, etc. are common systems for high temperature gas sensors and noble metal thin films such as Pt and/or Pd have also been employed, particularly in the case of $H_2$ sensing. Advanced design strategies can be employed to dramatically improve the performance of base metal oxide or noble metal films in terms of: (1) selectivity, (2) response time, (3) sensitivity, and (4) stability. Novel strategies can also be employed to impart unique optical or electronic properties useful for high temperature gas sensing that are not present in base metal oxide or noble metal thin films. Examples of such design strategies include:

- Multi-layered designs based on one or more functional metal oxide layers. (e.g. catalytic or physical filter overlayers deposited on a base metal oxide)
- Multi-phase composite or "nanocomposite" monolithic thin film layers. (e.g. mixed metal oxides or metal oxides mixed with metals)
- High surface area metal oxide films (e.g. tailored porosity or growth of nanowires on film surface)

Applications are sought in the area of novel thin film functional sensor layer designs to enable in-situ embedded sensors capable of selective gas sensing at extreme temperatures (maximum temperatures ranging from 500-1600$^{o}$C) and in relevant harsh conditions (long-term resistance to $H_2S$, stability in highly reducing / oxidizing environments) for advanced fossil energy applications. A specific fossil energy technology should be targeted (e.g. gas turbines, advanced boilers, solid oxide fuel cells, coal gasifiers), and the functional sensor layer should be tested in a working prototype sensor before project completion. Successful applicants will propose functional sensor layer designs that can be leveraged across a range of harsh environment sensing platforms and advanced fossil energy applications.

Questions – contact: Paul Ohodnicki, paul.ohodnicki@netl.doe.gov

### b. Distributed Low Cost Sensing for Power and Energy Systems

Grant applications are sought for the design and rapid prototyping of highly distributed low cost sensing concepts for power and energy systems. Measurements of interest include temperature, pressure, stress/strain, and vibration. Other key indicators of process condition and system status can be considered but relevance of the measurement must be justified. The emphases of this topic, however, will the potential for high number of sensors with widespread distribution and low cost. The ability to rapidly prototype the distributed sensing concepts in which to demonstrate measurement effectiveness and cost are preferred over those technologies that will require longer development cycles. Environments to be considered, but not necessarily included within one type of distributed sensor configuration, include ambient conditions through high temperature harsh environment (as defined by temperature up to 1000$^{o}$C and pressure up to 1000 psi).

Questions – contact: Susan Maley, susan.maley@netl.doe.gov

### c. Novel Approaches for Monitoring the Condition of Advanced Power Plants

Grant applications are sought for condition monitoring sensors capable of function in high temperature (800$^{o}$C-1200$^{o}$C) harsh environment that will directly contribute to improving system control, protect capital equipment investment, and promote safety through prevention of catastrophic equipment failure. Non-destructive and embedded techniques are of interest along with wireless communication capability.

Questions – contact: Susan Maley, susan.maley@netl.doe.gov

### d. Advanced Process Control Techniques using Distributed Intelligence

As new power generation technologies and systems mature, the plant which encompasses these systems will become inherently complex. In order to manage complexity, the process control architecture that supports the system will need to evolve to manage the complexity and achieve the goal of optimum performance. Research and development are being performed on novel control architectures that capitalize on computational capability and the ability to distribute this capability to the lower level where sensing and actuation are occurring in real time. These approaches depart from the traditional centralized control architectures and introduce concepts where networked communication of information (not data) and decision making capability at the lower levels thus enabling intelligence to be distributed and the sensing and actuation network to function in a self organizing manner. The topic seeks to expand on and integrate the various concepts using realistic system level scenarios and case studies. Phase I seeks to develop viable concepts for distributing intelligence for process control followed by Phase II development of the appropriate software and hardware to enable demonstration the novel concepts.

Grant applications are sought for the development of novel process control technique that distributes intelligence to the actuation and sensing level within a system. Phase I seeks to develop viable concepts in these areas and those concepts which include self organization, adaptive control, model based techniques, and data mining capability that can be distributed with a realistic sensing and actuation network to enable distributed intelligent control are encouraged.

Questions – contact: Susan Maley, susan.maley@netl.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: Steven Seachman, Steven.Seachman@netl.doe.gov

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## 15. COAL GASIFICATION TECHNOLOGIES

Coal gasification produces synthesis gas (primarily a mixture of H2 and CO), which can be converted into electricity, hydrogen, substitute natural gas, and other clean fuels, as well as high-value chemicals to meet specific market needs. Furthermore, while other sources of power may fluctuate, gasification systems operate on the low-cost, widely available, domestic feedstock of coal, and can be run on coal-biomass mixtures by using coal gasification to make hydrogen and then power, coal can be converted into electricity with a much smaller carbon footprint and significantly reduced contaminant emissions than typical for conventional power plants. For instance, a power plant run on clean hydrogen will only produce water as the flue gas. Coal gasification can also be used to co-produce clean power and chemicals or liquid fuels.

The U.S. Department of Energy‘s Office of Fossil Energy, through its National Energy Technology Laboratory, seeks to enhance the performance of gasification systems to make them cost competitive with alternative processes (e.g., pulverized coal power generation, natural gas combined cycle), thus enticing U.S. industry to implement the environmentally superior gasification-based processes. The enhancements sought will improve economics, improve gasification plant efficiency, improve process environmental performance (including carbon emission reduction), and increase process reliability.

**Grant applications are sought in the following subtopics:**

## a. Syngas Trace Contaminant Measurement System

The U.S. Environmental Protection Agency (EPA) is proposing standards to reduce toxic air pollution from power plants. The Hazardous Air Pollutants (HAPs) Maximum Achievable Control Technology (MACT) Standards, or Toxics Rule, proposed by the EPA, requires control of three hazardous air pollutants: mercury, hydrochloric acid (as a surrogate for the acid gases), and Particulate Matter (PM) (as a surrogate for the non-mercury metals).

Environmental and emissions monitoring is of special significance to the power generation industry, which will need to comply with forthcoming utility mercury reduction (Utility MACT) rules promulgated under the U.S. Clean Air Act. Measurement systems are needed that will enable the owners and operators of coal- and oil-fired electric utility steam generating units to collect data that will enable the EPA to assess emissions from these facilities.
Grant applications are sought for development of advanced measurement systems for monitoring these contaminants in IGCC plants. These measurement systems must be accurate, reliable, and low in capital and operating cost, and must represent a significant advancement over currently available technology for such measurements. The scope of the proposed project would include the development of instrumentation systems to measure trace constituents present in the syngas at various points in the IGCC process, and at the point where any such contaminants are emitted into the atmosphere (e.g., the stack). The criteria to demonstrate advancement over currently available technology would include accuracy, reliability, consideration of labor and capital costs, calibration requirements, and real-time measurement capability.

Grant applications must clearly describe the measurement techniques and instrumentation systems to be developed and must quantify the potential performance improvements and economic advantages of the proposed approach over conventional measurement systems when used in an IGCC plant.

The work plan should include a clear plan for developing the proposed measurement technology and a plan to test and prove the measurement system in an operating IGCC or coal gasification facility (as appropriate.)

Questions – contact: Darryl Shockley, darryl.shockley@netl.doe.gov

## b. Novel Multi-Contaminant Control Technologies for IGCC

The DOE gasification program is developing the next generation of technologies that, when integrated together in a modern IGCC plant, will provide the least-cost option for producing electric power when high levels of carbon capture and pollutant removal are required.

In order for a gasifier to be integrated with a combined cycle power plant, the syngas must first be cleaned of contaminants that could damage the turbines or contribute to environmental emissions. Typical syngas contaminants that need to be removed include particulates, sulfur gases (primarily

$H_2S$ and COS), ammonia, hydrogen cyanide, hydrogen chloride, alkali, and heavy metals. Conventional gas cleaning techniques typically require aqueous quenching and cooling of the syngas to around 100°F, followed by scrubbing using chemical or physical solvents, and finally absorption/adsorption of trace contaminants on solid sorbents. This cooling of the syngas and condensation of steam present in the gas stream followed by reheating of the gas stream before combustion of the cleaned syngas in the gas turbine introduces a significant energy penalty (exergy loss) for the overall system. In an effort to avoid this energy penalty and reduce the cost of the extra equipment, DOE is looking for cost-effective technologies for multi-contaminant removal that also achieve superior thermodynamic efficiency.

Grant applications are sought for development of novel multi-contaminant control technologies to remove trace metals and non-sulfur contaminants from IGCC syngas. Technology for "warm gas cleanup" of sulfur compounds is presently being demonstrated as part of the DOE program. Grant applications should focus specifically on technology for removal of trace components including $NH_3$ and/or hazardous air pollutants (e.g., Hg, As, Se, etc.) at warm gas conditions (e.g., temperature >400°F) that are able to support the proposed EPA air toxics rule for IGCC.

Grant applications must provide a systems conceptualization of how the novel multi-contaminant control technologies will operate, how they will integrate into an IGCC plant, and must also describe the potential performance and economic advantages (benefits) of the proposed approach over a conventional IGCC plant with CCS.

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

### c. Novel Energy Storage Concepts Integrated with IGCC that include CCS

Coal currently provides about 40 percent of world electricity and fast-paced growth in its use is projected for many countries, particularly among Asian economies. For this important energy source to continue to provide domestic and global prosperity and security, a balance is needed between energy security and concerns over the impacts of concentrations of greenhouse gases (GHGs) in the atmosphere – particularly carbon dioxide ($CO_2$).

The DOE gasification research, development, and demonstration (RD&D) program is developing the next generation of technologies that, when integrated together in a modern IGCC plant, will provide the least-cost option for producing electric power when high levels of carbon capture are required. The relative efficiency penalty for adding $CO_2$ capture to a conventional IGCC power plant is significant − 21 percent on average.

Grant applications are sought for novel concepts to enable load-shifting of the parasitic energy requirements for carbon capture and storage (CCS) to non-peak periods, thereby increasing the net power that can be delivered to the grid during peak demand periods while still maintaining a high average carbon capture percentage (>90%). An example of such a concept is the storage of rich CO2-laden solvents for off-peak regeneration and compression/injection [See References below]. Grant applications for grid-level energy storage concepts that are not integral parts of the IGCC/CCS process (e.g., batteries, flywheels, compressed air energy storage, etc.) are **not** being sought.

Grant applications must provide a systems conceptualization of how the energy storage system will integrate into an IGCC plant and must also describe the potential performance and economic advantages of the proposed approach over a conventional IGCC plant equipped with CCS. The work plan may include small-scale testing and collection of experimental data when such data are not presently available.

The work plan should include development of a computer simulation model for the process (e.g., ASPEN model) that can be used to show how power output of the plant will respond to demand and can be used to predict the cost and performance advantages for the process. The model should be able to calculate plant thermal efficiency and emissions with as a function of time as well as calculate time-averaged performance. Sufficient data shall be provided for DOE's National Energy Technology Laboratory (NETL) personnel to be able to conduct a benefits analysis to confirm the overall reduction in cost of power production and the amount/percentage of the parasitic energy requirements that are load-shifted.

Questions – contact: Meghan Napoli, meghan.napoli@netl.doe.gov

### d. Hybrid Integrated Concepts for IGCC (with CCS) and Non-Biomass Renewable Energy (e.g. Solar, Wind)

Wind and solar energy are the fastest growing renewable sources of electric energy with U.S. However, the output of wind and solar power plants is intermittent and variable − they do not produce power at all times of day and cannot be controlled by grid operators. The U.S. electric system, which was developed throughout the 20$^{th}$ century, was largely designed around base load power plants such as coal and nuclear, and other dispatchable generators that can provide power at the request of grid operators who must be able to respond to changes in demand.

The DOE gasification research, development, and demonstration (RD&D) program has a long history that ultimately led to construction of the only two currently operating coal-based integrated gasification combined cycle (IGCC) plants in the U.S. The DOE program is now developing the next generation of technologies that, when integrated together in a modern IGCC plant, will provide the least-cost option for producing electric power when high levels of carbon capture are required. Grant applications are sought for novel design concepts for integrating new IGCC plants with a non-biomass renewable energy resources (e.g., wind and solar). Such integrated hybrid plants could potentially reduce the impacts of the variability of renewable energy sources, reduce the carbon footprint of the coal-fired base load plant, increase reliability of the electrical grid, facilitate a higher penetration of intermittent renewable resources into the power grid, and help to make more efficient use of available generation resources.

Grant applications must provide a systems conceptualization for the design of new IGCC plant that includes specific novel process design features that will enable the integration of such renewable energy resources into the system. The application must also describe the potential performance and economic advantage of the proposed approach compared to a conventional IGCC plant equipped with CCS and an equivalent but separate (stand-alone) wind and/or solar generator. The proposal must adequately describe the cost, environmental, operational, and/or reliability benefits anticipated from the hybrid integration including the potential to increase wind/solar penetration into the grid.

Questions – contact: Arun Bose, arun.bose@netl.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: Arun Bose, arun.bose@netl.doe.gov

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3. "Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies, Final Report," EPA-430/R-06/006 July2006, http://www.epa.gov/airmarkets/resource/docs/IGCCreport.pdf


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1. "A Review Of Large-scale Renewable Electricity Integration Studies," Paulina Jaramillo and Paul Hines, The First Integration and Policy Workshop for the RenewElec Project, Carnegie Mellon University, Pittsburgh, PA, Oct 21-22, 2010, https://wpweb2.tepper.cmu.edu/rlang/RenewElec/Integration%20studies.pdf.
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## 16. TECHNOLOGIES FOR CLEAN FUELS AND HYDROGEN FROM COAL

The Hydrogen and Clean Coal Fuels Program supports DOE's strategic goals – increasing energy security, reducing the environmental impact of energy use, promoting economic development, and encouraging scientific discovery and innovation – by researching and developing novel technologies for the economic conversion of coal, America's largest domestic fossil energy resource, into hydrogen and other clean fuels. With carbon management and/or capture and storage, coal can produce these fuels in a manner that addresses concerns regarding the build-up of atmospheric carbon dioxide concentrations. Coal resources offer an attractive option for producing hydrogen that can be utilized for power generation or transportation. Hydrogen-rich liquids and substitute natural gas (SNG) can be produced from coal and used directly or as an alternative route to hydrogen production. Additionally, innovative technologies and methods to produce, deliver, and utilize hydrogen from coal will provide a clean and sustainable alternative to imported fuels.

**Grant applications are sought in the following subtopic:**

### a. Concepts for Enhanced Catalysts for Water-Gas-Shift and Fischer-Tropsch Processes for Gases from Co-Mingled Coal and Biomass Gasification

Recent systems studies have shown that the addition of biomass to a coal gasification feedstock would be beneficial. This process, known as the Coal-Biomass-to-Liquids (CBTL) process employs domestic coal and biomass feedstocks, has a better greenhouse gas footprint than conventional processes for petroleum fuels, and is projected to be economically competitive at a world oil price significantly below $100 per barrel. Improvements to several plant unit operations offer particular opportunities. For example, the use of water-gas shift (WGS) and Fischer-Tropsch (FT) technologies are well-known for converting syngas to high hydrogen content liquids. However, the current commercial catalysts used in WGS processes and FT syntheses are intrinsically sensitive to small amounts of poisons.

In commercial operation, these catalysts must be replaced or regenerated after a certain operational period. The specifics of this syngas cleaning are based on economic considerations: the investment in gas cleaning must be weighed against decreased production due to catalyst poisoning. Therefore, new or novel catalysts that are resistant to contaminants may aid in the overall cost of the produced liquid fuel. These syngas contaminants, which result from the gasification of co-mingled coal and biomass, include (1) sulfur species; trace toxic metals, halides, and nitrogen species from coal, and (2) KCl and NaCl from biomass.

Grant applications are sought for novel WGS and/or FT catalysts, or catalyst-related improvements that will result in improved CBTL plant efficiency and/or cost. In addition to the development of catalysts that may be resistant to contaminants, approaches that address other catalyst related challenges are also of interest, provided that the contaminants are removed prior to the WGS or FT process. These challenges include the optimization of overall yields of desired fuel fractions for FT catalysts; improved CO conversion for WGS catalysts; improvements that result in maintenance of sustained catalyst activity; and the need for less costly catalyst materials.

Temperature, pressures, and feed compositions use in experiments should be justified in terms of being relevant for integrating the proposed concept within a CBTL process; that is, the catalysts should be targeted for use in the temperature and pressure ranges of commercial WGS and FT catalysts, or they should be justified (e.g., thermodynamically) for the proposed test conditions. Literature reviews are not within the scope of this subtopic and will be declined.

Questions – contact: Jason Hissam, jason.hissam@netl.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: Jason Hissam, jason.hissam@netl.doe.gov

**References**

**Subtopic a:**


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2. 2. "Hydrogen from Coal Program Research, Development, and Demonstration Plan for the Period 2010 through 2016", External Draft, Sept. 2010, http://www.netl.doe.gov/technologies/hydrogen_clean_fuels/refshelf/pubs/20100908_Draft_H2fromCoal%20RDD_final.pdf.
3. 3. "NETL Test Protocol – Testing of Hydrogen Separation Membranes", DOE/NETL2008/1335, October 2008, http://www.netl.doe.gov/technologies/hydrogen_clean_fuels/refshelf/pubs/Membrane%20test%20protocol%20v10_2008_final10092008.pdf.

4. 4. "Affordable, Low Carbon Diesel Fuel from Domestic Coal and Biomass", DOE/NETL-2009/1349, January 2009, http://www.netl.doe.gov/energy-analyses/pubs/CBTL%20Final%20Report.pdf.

## 17. CLIMATE CONTROL TECHNOLOGIES FOR FOSSIL ENERGY APPLICATIONS

Coal is predicted to continue to dominate power generation for the next 25 years, and since power generation from coal is a significant source of carbon dioxide ($CO_2$) emissions, the reduction of these emissions is a critical research need. The United States has made a commitment to work toward the long-term reduction of $CO_2$ emissions, which in the USA originate mainly from the combustion of fossil fuels for energy production, transportation, and industrial processes, with about one third of US anthropogenic $CO_2$ emissions coming from power plants. The DOE continues to make progress toward the goals of lowering the cost of $CO_2$ capture and ensuring that $CO_2$ can be safely and permanently stored in geologic formations in a process known as carbon capture and storage (CCS). Additionally, as carbon capture technology has advanced, the concept of $CO_2$ utilization has attracted more interest due to its potential not only to reduce emissions but also as a means to generate revenue to offset the cost of capture. To assist in accelerating the implementation of CCS at commercial scale DOE seeks innovative technologies and methods that 1) reduce the cost and energy requirements of $CO_2$ capture; 2) reduce the cost and improve accuracy of field monitoring instrumentation; and 3) promote $CO_2$ utilization.

**Grant applications are sought in the following subtopics:**

### a. Advanced Solvents for $CO_2$ Capture from Existing Coal-fired Power Plants

Significant research and development is currently being pursued for new technologies to separate and capture $CO_2$ from flue gas streams produced by existing coal-fired electric generating power plants. Aqueous amine absorption is the state of- the-art technology for post-combustion $CO_2$ capture from flue gas. However, amine absorption has a number of drawbacks, including significant capital and operating costs. Therefore, grant applications are sought to develop solvent based technologies that can substantially lower the cost of $CO_2$ capture from flue gas produced by existing coal-fired power plants. Incremental improvements on amine-based systems are not sought. The research effort should demonstrate the viability of the technology to perform with actual flue gas compositions generated from existing coal-fired power plants. Technologies should be capable of 90% or greater reduction in $CO_2$ emissions per net kWh and result in less than a 30% increase in the cost of energy services.

Solvent-based systems, typically using amines, are in commercial use in scrubbing $CO_2$ from industrial flue gases and process gases. However, they have not been applied to removing large volumes of $CO_2$ as would be encountered in a PC-fired utility boiler flue gas. Key technical challenges to solvent based systems for capturing $CO_2$ from coal-fired power plants include: (1) large flue gas volume; (2) relatively low $CO_2$ concentration; (3) flue gas contaminants; and (4) high parasitic power demand for solvent recovery. The liquid and gas are typically contacted in a countercurrent packed column or a spray tower. Commercial $CO_2$ capture solvents are typically amine-based. In responding to this subtopic applicants should demonstrate a thorough understanding of the technology being proposed. The applicant should provide information relevant to overcoming the technical challenges identified above in achieving the DOE goal.

The applicant should also provide a description of all auxiliary power required, theoretical maximum $CO_2$ capacity and target working capacity (in lb $CO_2$/lb solution), description of the stripper configuration, information about the chemical and thermal stability of the solvent, the chemical reactions for the $CO_2$ absorption/regeneration cycle (and if available, kinetic data, expected operating temperatures, theoretical regeneration energy, and target regeneration energy as a function of working capacity), the solvent composition and anticipated cost range (if manufactured in large quantities), the solvent molecular weight or average molecular weight (mixed solvents) and the boiling point of the solvent (or solvents if mixed solvents). Since this subtopic deals with capture from an existing coal-fired power plant, applicants should include a block flow diagram of how their technology would be retrofitted to a typical pulverized coal fired power plant.

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

**b. $CO_2$ Utilization to Develop Valuable Products**

As carbon capture and storage (CCS) technologies have advanced, the concept of $CO_2$ utilization has attracted more interest due to the potential of $CO_2$ as a useful commodity chemical. In a carbon-constrained economy it is anticipated that large volumes of $CO_2$ will be available from fossil fuel–based power plants and other $CO_2$-emitting industrial plants equipped with $CO_2$ emissions control technologies. While DOE is supporting efforts to demonstrate the safe and permanent storage of captured $CO_2$, a large surplus of captured $CO_2$ presents an opportunity to use it as an inexpensive raw material.

To explore this concept, the DOE has created a $CO_2$ utilization focus area as part of its Carbon Storage Program. The goals of the $CO_2$ utilization focus area are to identify and develop a suite of technologies that can (1) increase the value and demand for $CO_2$ captured from large point sources to help offset capture costs, (2) reduce $CO_2$ emissions, and (3) reduce the demand for petroleum based feedstocks and products. Grant applications are sought for the development of novel, or the enhancement of existing, $CO_2$ Utilization technologies that support at least one of the $CO_2$ Utilization goals stated above. Approaches of interest include, but are not limited to, (1) $CO_2$ as feedstock for fertilizer production; (2) $CO_2$ as feedstock for polymers or other commodity chemicals; and (3) $CO_2$ as a feedstock for building materials.

Preference will be given to proposals that adequately consider the proposed technology's potential impact on the supply and demand of the end-product. Additionally, the proposal should include a preliminary life cycle analysis to demonstrate that the proposed technology will not create more $CO_2$ than is utilized and at a cost of no more than \$10/tonne. Other desirable attributes that will enhance a proposal's technical merit are:

- Improves energy efficiency (i.e., requires less power per unit of product than the conventional process)
- Has no or low water requirement
- Utilizes and/or reduces waste streams

- Replaces one or more toxic materials that require special handling to protect human health and the environment

DOE is currently supporting multiple small- and large-scale CCS RD&D projects to demonstrate the technical and economic feasibility of CCS; and while advances have been made to reduce the cost of implementation, cost remains a primary concern. Recent studies support the approach that $CO_2$ utilization should focus on identifying technologies and opportunities that can generate a revenue stream for $CO_2$ suppliers to assist in reducing capture costs, thereby accelerating CCS implementation. Consequently, technologies that support this approach are of particular interest.

IMPORTANT NOTE: Other programs in multiple government agencies including DOE are supporting R&D efforts to develop technologies that use $CO_2$ for $CO_2$-Enhanced Oil Recovery (EOR), $CO_2$-Enhanced Coalbed Methane (ECBM) production, $CO_2$-Enhanced Gas Recovery (EGR), $CO_2$-Enhanced Geothermal Systems (EGS), and algae cultivation, as well as $CO_2$ as a feedstock for making fuels, biofuels, fuel precursors, syngas, hydrogen, and carbon monoxide. **Therefore these approaches are not of interest for this subtopic, and proposals based on these approaches will be declined.**

Approaches that use $CO_2$ to produce or enhance energy products such as power, steam, heat, or electricity will be considered. However, proposals based on this approach may be redirected to another, more appropriate subtopic or declined as unresponsive regardless of technical merit if the primary benefit of deploying the proposed technology is viewed as unsubstantial with respect to the $CO_2$ Utilization goals.

Questions – contact: Darin Damiani, darin.damiani@netl.doe.gov

### c. Advanced Monitoring Technologies for Geologic $CO_2$ 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 for surface, near-surface, and subsurface applications 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 quantify $CO_2$ emissions in the unlikely event that $CO_2$ migrates out of the injection zone, detect leakage pathways through existing faults, fractures, and/or wellbores, monitor and image the $CO_2$ plume, and/or monitor the pressure front for carbon storage projects. Proposals are sought that focus on developing new, or enhancing existing, MVA tools for monitoring atmospheric (surface), near-surface, and/or sub-surface $CO_2$ with improved accuracy, continuous (real-time) monitoring capabilities, and/or automation of the interpretation of the results. Preference will be given to technologies that demonstrate enhanced performance at reduced cost.

IMPORTANT NOTE: Approaches in developing new or enhancing existing modeling technologies are not of interest for this subtopic and grant applications using these approaches will be declined for review.

Questions – contact: Robert Noll, robert.noll@netl.doe.gov

## d. 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: Andy Aurelio, isaac.aurelio@netl.doe.gov

**References**

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**Subtopic c:**

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2. DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap, U.S. DOE National Energy Technology Laboratory (NETL), December 2010. Full-text available at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/CCSRoadmap.pdf.
3. Carbon Sequestration Program: Technology Program Plan, U.S. DOE National Energy Technology Laboratory (NETL), February 2011. Full-text available at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/2011_Sequestration_Program_Plan.pdf.
4. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide ($CO_2$) Geologic Sequestration (GS) Wells, U.S. Environmental Protection Agency, December 2010. Full-text available at: http://www.gpo.gov/fdsys/pkg/FR-2010-12-10/pdf/2010-29954.pdf.
5. The Clean Air Act, U.S. Environmental Protection Agency, 2008. Full-text available at: http://www.gpo.gov/fdsys/pkg/USCODE-2008-title42/pdf/USCODE-2008-title42-chap85.pdf.

## 18. ADVANCED TURBINE TECHNOLOGY FOR IGCC POWER PLANTS

Integrated Gasification Combined Cycle (IGCC) power plants are attractive alternatives to current pulverized coal technologies in large-scale stationary applications. IGCC systems are very efficient, with efficiencies ranging from 35 to 45 percent (depending on system configuration and size). They also are environmentally friendly, emitting lower levels of pollutants and particulates. However, in order to meet long-term Turbine Program goals, which will target efficiencies greater than 50%, the inlet temperature may need to be raised even further than the current state-of-the-art (to 1500ºC (2732 ºF) or higher). Therefore, this topic seeks advances in the design and manufacturability of high temperature materials and hot gas path component sealing and leakage control techniques, two enabling technologies for higher efficiency and lower emissions.

**Grant applications are sought only in the following two subtopics.**

### a. High-Yield Manufacturing of Single Crystal Gas Turbine Components

Nickel superalloys are used for hot gas path components in gas turbines because of their excellent creep resistance properties. To achieve their maximum mechanical capability these materials must be cast as single crystals. Although casting yields have improved, they have not improved sufficiently to enable the wide-spread use of single crystal superalloys in industrial gas turbines. Low yields have been associated with process-related defects such as shell/mold cracking, core deformation/shifting/breakthrough, and metal hot tearing/cracking; metallurgical melt-related defects such as freckle formation, high angle boundary formation, grain nucleations, and shrinkage/porosity; and post-cast defects such as incipient melting and recrystallization during high temperature solution heat treatment.

Grant applications are sought for research and development to explore innovative approaches to increase the yield rates of single crystal castings for high-temperature gas turbine applications. This could be through compositional adjustments and/or casting process improvements relative to the state of the art. Development of models correlating casting defects to composition and process variables is encouraged.

Grant applications must provide details regarding material compositions, process parameters, and technical capabilities for assessing feasibility. A clear path to an improvement in casting yield should be demonstrated. Costs of capital equipment, process consumables, and casting materials should be discussed relative to the state of the art. Technical requirements for gas turbine applications should be addressed, such as component geometry tolerances, the ability to fabricate serpentine internal cooling passages, and weldability.

Questions – contact: Robin Ames, robin.ames@netl.doe.gov

**b. Advanced Gas Turbine Sealing and Leakage Control Strategies**

Advanced gas turbine engines consist of engineered gaps and clearances to permit relative movement between stationary and rotating parts and also to allow for relative thermal expansion between adjacent parts that operate at different temperatures. As advanced turbines continue to increase firing temperatures, reducing the leakage associated with these critical hot gas path component interfaces will result in a significant improvement in overall turbine performance, efficiency and power output.

Specific technologies need to be developed to improve sealing in the radial gap between tips of rotating unshrouded turbine blades and stationary shrouds as well as shaft sealing for radial excursions. Blade tip seals may be subjected to temperatures in excess of current metallic temperature limits, high pressure differentials, and large radial transients. Because the turbine blades are unshrouded, any seal element will be subjected to periodic changes in the adjacent rotor surface (i.e., individual blade tips), making the use of conventional compliant seal technologies (such as brush seals) very difficult. Approaches to be considered might include, but not limited to, the use of erosion-resistant abradable materials on the inner surface of the stationary shrouds, and/or compliant, flexible sealing elements that move radially during transient events. Shaft sealing technologies are challenged by gas turbine operating conditions that include large radial excursions, and significant variation in the location of the shaft relative to the stator. Compliant, non-contacting seals that can both follow the rotor surface through radial excursions and accommodate variation in the average clearance between rotor and stator would provide a valuable benefit in performance and minimize engine-to-engine variations.

Grant applications are sought for research and development to explore specific sealing improvements in the areas of the unshrouded blade tips and/or shaft sealing. Grant applications should address the technology of the proposed concept(s) relative to the current state of the art, substantiate the costs and benefits, and evaluate a validation strategy with existing gas turbine equipment.

Questions – contact: Robin Ames, robin.ames@netl.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: Robin Ames, robin.ames@netl.doe.gov

**References**

**Subtopic a:**


1. U.S. Department of Energy. The Gas Turbine Handbook. Section 4.1.1-3. 2006. http://www.netl.doe.gov/technologies/coalpower/turbines/refshelf/handbook/TableofContents.html.
2. J.C. Schaeffer, "Single Crystal Materials Technology for Advanced Gas Turbine Applications," presentation at Power-Gen Europe 2005, Milan, Italy, June 28-30, 2005.
3. M. Konter and M. Thhmann, "Materials and Manufacturing of Advanced Industrial Gas Turbine Components," Journal of Materials Processing Technology, 117 (3), 2001, 386-390. ISSN: 0924-0136. http://www.elsevier.com/wps/find/journaldescription.cws_home/505656/description


**Subtopic b:**


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2. "Sealing in Turbomachinery," 2006, AIAA Journal of Propulsion and Power, Vol. 22, No. 2, Mar-April, 2006 ISSN: 0748-4658 http://www.aiaa.org/content.cfm?pageid=322&lupubid=24.
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## 19. FUEL CELL TECHNOLOGIES FOR CENTRAL POWER GENERATION WITH COAL

Improved power generation technologies will help the nation make more efficient, cost-effective, and environmentally-responsible use of its abundant domestic coal reserves. This topic seeks advances in fuel cell technology for central coal power plants.

Solid oxide fuel cell (SOFC)-based systems are attractive alternatives to current technologies for coal-fueled central generation. SOFC systems are very efficient, with efficiencies ranging from 40 to over 60 percent (depending on system configuration). Electrochemical conversion in a SOFC takes place at lower temperatures (650ºC to 950ºC) than combustion-based technologies, resulting in decreased emissions, particularly nitrogen oxides. Furthermore, in a carbon-constrained world, SOFCs offer considerable opportunities with respect to both lower CO2 generation (as a result of higher efficiency) and increased CO2 capture. With these advantages, systems containing improved fuel cell technology, in combination with heat recovery subsystems and commercial CO2 capture technology, will meet DOE goals that include 45-50% efficiency (coal HHV to electrical power), <2ppm NOx, and 90% carbon capture. Consistent with these goals, the DOE-sponsored Solid State Energy Conversion Alliance (SECA) will develop commercially-viable ($700/kW) SOFC power generation systems.

**Grant applications are sought in the following subtopics.**

### a. Ceramic Components and Insulation for SOFC Systems

SOFC-based power systems contain many engineered ceramic components. Examples include the cells themselves, cell supports, manifold components, and insulation. These components make up a considerable share of the system cost. Furthermore, the structural and chemical stability of these components relative to the anticipated 40,000 hour service life is unproven. Applications are sought to develop low-cost processes for manufacturing engineered ceramic fuel cell stack components. The processes should be amenable to high-volume manufacturing. Specific technical requirements will be dependent upon the design of the SOFC system with which it is associated; therefore, Applicants are encouraged to consult with the SECA Industry Teams with respect to their detailed system specifications.

Technical details should be provided for the components and their associated fabrication process illustrating technical feasibility. Manufacturing tolerances and stability in the high-temperature system environment should be addressed. Costs in both low- and high-volume manufacturing scenarios should also be addressed.

Questions – contact: Briggs White, briggs.white@netl.doe.gov

### b. Aluminized Coatings for SOFC Applications

Low cost stainless steels are desired for both interconnects and balance of plants components to reduce costs for SOFC systems. The SOFC stack is provided mechanical structure by the interconnects, which also serve to conduct electricity from the anodes to the cathodes within each cell. The interconnects also provide physical separation of the air and fuel streams. The relatively high operating temperatures of SOFCs and the presence of oxygen and fuel, however, result in oxidation of stainless steel interconnects and balance-of-plant components. These materials experience surface corrosion and gaseous corrosion products formation resulting in the loss of metal along with chromium poisoning of the SOFC cathode, degrading SOFC stack performance over time.

Much effort is currently being expended to protect SOFCs' steel components by using protective coatings developed and demonstrated via processes involving aluminization. Although industrial pack cementation and vapor aluminization processes are well-established, the efficacy of such coatings with respect to Cr-species volatility, on a range of suitable alloys (CTE compatible with the various SOFC systems) requires further study under SOFC operating conditions. The following have proven challenging for coating designers in terms of proper selection of bulk alloys and surface coatings: 1) engineering effective combinations of oxidation resistance, electronic conductivity and reduction of chromium volatility; 2) mitigation of chemical interaction on steel components; and 3) SOFC component compatibility.

Grant applications are sought to identify, test and select candidate iron and nickel based alloys and aluminized coatings for applications in air and thermal management units of advanced SOFC systems. Approaches of interest include but are not limited to:

- Attaining insights into chromium evaporation, degradation and corrosion (both surface and bulk) and protection over long timeframes.
- Develop aluminization processes that provide a protective layer that remains stable and prevents chromium evaporation over time under dual atmospheres of reformate fuels and ambient humidified air at temperatures of between 700C and 900C. The coating should be robust through multiple thermal cycles, have no harmful interaction with SOFC cells and seals, and be robust through additional thermal processing of the coated hardware at up to 1000C.
- Develop lower-cost slurry/spray based coatings, having as effective Cr-volatility mitigation as industrial pack cementation and vapor coatings. This alternative approach should provide simplicity of process that can be used to coat alloy-based instrumentations that are used in SOFC systems such as thermocouples and pressure taps. The process should also be usable for applying coatings onto substrates in a selective manner and at low cost and high manufacturing volume.
- Develop alternate coating compositions from alumina (Si-based).

Questions – contact: Rin Burke, patcharin.burke@netl.doe.gov

## c. Low-Cost Alloys for High-Temperature SOFC System Components

SOFC-based power systems for coal-based power generation applications contain considerable amounts of expensive nickel-based alloys for a variety of components, such as heat exchangers and piping used to convey process gas mixtures. In addition to being expensive, these alloys are difficult to weld and too stiff for applications requiring expansion/contraction during heat-up and shut-down. Low-cost alloys are desired that can meet the SOFC system component requirements and overcome the drawbacks of nickel-based alloys.

Applications are sought to identify and/or develop low-cost alloys amenable to the high-temperature requirements of an SOFC system. Specific technical requirements will be dependent upon the design of the SOFC system with which it is associated; however, the following general requirements must be addressed: low chrome volatility for piping carrying air to the SOFC cathode inlet, weldability, and flexibility relative to high-temperature bellows. Applicants are encouraged to consult with the SECA Industry Teams with respect to their detailed specifications.

Applications should include the technical details of the proposed alloy development and the associated fabrication process illustrating technical feasibility. Costs in both low- and high-volume manufacturing scenarios should be addressed.

Questions – contact: Briggs White, briggs.white@netl.doe.gov

**d. 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: Briggs White, briggs.white@netl.doe.gov

**References**

**Subtopics a-c:**


1. SECA Website at www.seca.doe.gov.
2. Fuel Cell Handbook, EG&G Services, Parsons, Inc., 7th Edition, November 2004. Full text available at: http://www.netl.doe.gov/technologies/coalpower/fuelcells/seca/refshelf.html.


## 20. OIL AND GAS TECHNOLOGIES

Much of the remaining oil resource in the U.S. cannot be recovered by conventional means, and advanced technologies are required for economical and environmentally benign extraction. This topic seeks to develop technology that will lead to more efficient production of oil by furthering the development of innovative tools or methods to reduce exploration, processing, and field development costs – and/or improve recovery efficiency – related to the development and production of oil from residual oil, heavy oil, and fractured oil-bearing shale resources.

**Grant applications are sought in the following subtopics:**

## a. Enhanced Recovery of Petroleum Resources

Grant applications are sought to develop innovative tools or methods to reduce geophysical, environmental impact reduction or mitigation, oil processing, or field development costs – and/or improve recovery efficiency – related to the development and production of oil from residual oil, heavy oil, and fractured oil-bearing shale resources. For these unconventional oil resources, approaches of interest include methods to: (1) reduce the technical and environmental constraints on production, (2) improve overall oil recovery efficiency. Specific technology interests include:

- Residual Oil:
  - Optimized well design and placement methodologies.
  - Technologies for increasing the viscosity of injected CO2 relative to reservoir fluids.
  - Miscibility extension technologies.
  - Novel approaches for increasing CO2 injection volumes.
  - Enhanced reservoir visualization technologies.
- Heavy Oil:
  - Reducing sand production from thermally stimulated wells.
  - Improving the efficiency of steam generation and injection.
  - Advanced technologies for improving steam or hot water sweep efficiency.
  - Advancing crude upgrades for heavy oil.
  - Enhanced reservoir visualization technologies.
- Oil from Fractured Shales:
  - Advanced drilling and completion technologies tailored to shale reservoirs.
  - Enhanced reservoir visualization technologies.

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: Eric Smistad, eric.smistad@netl.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: Eric Smistad, eric.smistad@netl.doe.gov

**References**

**Subtopic a:**


1. Applicants may review information about oil and natural gas programs at NETL's website: http://www.netl.doe.gov/technologies/oil-gas/index.html.
2. Applicants may review the draft report entitled "Unconventional Fossil Energy: Domestic Resource Opportunities and Technology Applications": http://www.netl.doe.gov/technologies/oilgas/publications/EPreports/UnconventionalFossilEnergy_Reportdraft4-23-10v2.pdf.

## 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. New nuclear plants will be needed to meet increasing electricity demand without greenhouse gas emissions, and to provide high temperature process heat for industrial applications and the production of hydrogen for fertilizers and bio-fuels. These new nuclear plants will feature improvements and developments in nuclear reactor technology for existing and evolutionary light water reactors, advanced very high temperature gas-cooled reactor design technology, advanced instrumentation and control (I&C) systems that perform well in very high temperature, high fluence and radiation environments, and nuclear fuel that is manufactured with advanced fabrication, characterization and recycling techniques.

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, proliferation resistance, and security barriers through research, development, and demonstration as appropriate.

In addition to its primary mission, the Office of Nuclear Energy performs several mission-related functions including providing:

- International engagement in support of the safe, secure, and peaceful use of nuclear energy as well as support to other Department offices and other federal agencies on issues related to the international use of civilian nuclear energy
- The capability to develop and furnish nuclear power systems for use in national security and space exploration missions
- Oversight for specifically assigned front-end fuel cycle responsibilities
- Stewardship of the DOE Idaho Site

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

### 21. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Nuclear power provides over 20 percent of the U.S. electricity supply without harmful greenhouse gases or air pollutants, including those that may cause adverse global climate changes. New methods and technologies are needed to address key issues that affect the future deployment of nuclear energy and to preserve the U.S. leadership in nuclear technology and engineering, while reducing the risk of nuclear proliferation.

This topic addresses several of these key technology areas: improvements in nuclear reactor technology for existing light water reactors (LWR) and evolutionary LWR and gas-cooled reactor designs, advanced instrumentation and control (I&C) for very high temperature gas-cooled reactor applications, advanced I&C for use in high neutron irradiation environments for gas-cooled reactor designs, capabilities and technologies that support the commercialization of innovative small modular reactor designs, and advanced technologies for the fabrication, characterization and non-destructive testing of high quality nuclear reactor fuel for LWR and Generation IV reactor designs of varying power level which include advanced fuel cycle management related technologies. Gas-cooled reactor technology is being developed through the Next Generation Nuclear Plant (NGNP) Program. Of particular interest are grant applications that propose the use of the Idaho National Laboratory's Advanced Test Reactor National Scientific User Facility for Phase I and/or Phase II.

**Grant applications are sought in the following subtopics.**

## a. New Technology for Improved Nuclear Energy Systems

Improvements and advances are needed for reactor systems and component technologies that ultimately would be used in the design, construction, or operation of existing and future nuclear power plants, and Generation IV nuclear power systems [see references 1-5]. Grant applications are sought: (1) to improve and optimize the performance of the nuclear power plant and its systems, along with component instrumentation and control, by developing and improving the reliability of advanced instrumentation, thermocouples, sensors, and controls, and by increasing the accuracy of measuring of key reactor and plant parameters [6, 7]; (2) to improve monitoring of plant equipment performance and aging, using improved diagnostic techniques for in-service and non-destructive examinations [8]; (3) to improve Non-Destructive Examination methods and in-service inspection techniques inside the radiation environment of High Temperature Gas-Cooled Reactors (HTGR) for large graphite and ceramic components; (4) for advanced instrumentation, sensors, and controls for very high temperature gas cooled reactor (Generation IV) designs that can withstand temperatures in excess of 1800°C during accident conditions; (5) for advanced instrumentation, sensors, and controls for the very high irradiation environments ($> 10^{15}$ $n/cm^2sec$ neutron flux levels) that will be encountered in advanced Generation IV high temperature gas reactor designs and sodium fast reactors [7, 9, 10]; and (6) to improve and optimize the efficiency of nuclear power plants by developing technologies that significantly improve the utilization of waste heat (e.g. decay heat from spent nuclear fuel or other waste heat systems).

Grant applications that propose to use the Idaho National Laboratory (INL) Advanced Test Reactor (ATR) National Scientific User Facility [11] for demonstrating the performance of the instrumentation, sensors, or thermocouples are particularly sought and will need to prove technical feasibility prior to their insertion into the ATR for irradiation testing.

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 for Generation IV Reactor Designs, and Fuel for Advanced Fuel Cycle Research and Development

Improvements and advances are needed for the fabrication, characterization and non-destructive examination of nuclear reactor fuel with technologies that could: (1) develop advanced automated, accurate, continuous vs. batch mode process techniques to improve TRISO coated particle fuel: (a) fabrication, (b) accurate sorting methods to replace manual sieving or "tabling" methods that determine size, shape, and aspect ratio to remove aspherical or under/over-sized particles, (c) characterization, and (d) non-destructive evaluation testing of TRISO particles and compacts for Advanced Gas-Cooled Reactors/NGNP applications [12, 13]; (2) provide new innovative LWR fuel concepts with a focus on improved performance (especially under accident scenarios), and advanced fuel fabrication techniques capable of dealing with actinide-bearing ceramic and metal alloys, and; (3) develop radiation-tolerant electronics for characterization instrumentation for use in hot cell fuel/clad property measurements [9, 10]. 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 may be proposed to use the INL ATR National Scientific User Facility [11], and its hot cells and fuel fabrication laboratories, or the Oak Ridge National Laboratory Advanced Gas Reactor TRISO fuels laboratory facilities [12, 13] to demonstrate the techniques and equipment developed. Actual nuclear fuel specimens may be considered for ATR or ORNL High Flux Irradiation Reactor (HFIR) will need to prove technical feasibility prior to their insertion into the ATR or HFIR for irradiation testing.

Grant applications that address the following areas are NOT of interest and will be declined: Spent fuel separations technologies used in the Fuel Cycle Research and Development Program [9, 10] 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 sensitivity, resolution, radiation hardness, while decreasing intrusiveness on operations and the cost to manufacture. In addition, concepts and integration of safeguards features into facility/process design are being sought. Grant applications are sought for: (1) Sensors based on radiation detection; (2) New technologies to replace He-3 for neutron detection in accountability instruments; (3) New active interrogation methods, including basic nuclear data (neutron and photo fission, nuclear resonance fluorescence); (4) Non-radiation based (stimulated Raman, laser-induced breakdown spectroscopy, fluorescence, etc.); and (5) Safeguards and security by design concepts. 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.

Grant applications that address sensitive (e. g., IAEA safeguards for special nuclear materials) technologies [10] 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 (1) provide software engineering support for computer codes in supporting nuclear energy, and (2) can integrate the resultant codes into a web services framework.

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

**References**

**Subtopics a-d:**

1. U.S. DOE Office of Nuclear Energy, Home Page. (URL: http://www.nuclear.gov.
2. Generation IV Nuclear Energy Systems, Office of Nuclear Energy: http://nuclear.energy.gov/genIV/neGenIV1.html.
3. Nuclear Energy Research Initiative (NERI), Office of Nuclear Energy: http://nuclear.energy.gov/neri/neNERIresearch.html.
4. Nuclear Power 2010, Office of Nuclear Energy: http://nuclear.energy.gov/np2010/overview.html .
5. Light Water Reactor Sustainability (LWRS) Program, Office of Nuclear Energy: http://nuclear.energy.gov/LWRSP/overview.html.
6. Miller, D. W., et al., "U. S. Department of Energy Instrumentation, Controls and Human-Machine Interface (IC & HMI) Technology Workshop," Gaithersburg, MD, May 15-17, 2002, IC&HMI Report, September 2002. Full text available at: http://www.nuclear.gov/pdffiles/NE1_ICHMI_Report.pdf.
7. Hallbert, Bruce P., et al., "Report from the Light Water Reactor Sustainability Workshop on Advanced Instrumentation, Information and Control Systems and Human-system Interface Technologies," held March 20-21, 2009, Columbus, Ohio, INL/EXT-09-16631, August 2009. Full text, available at: https://inlportal.inl.gov/portal/server.pt/community/lwrs_program/442/program_documents. and Dudenhoeffer , D., et al, " Technology Roadmap on Instrumentation, Control, and Human Machine Interface to Support DOE Advanced Nuclear Power Plant Programs," INL/EXT-

0611862, March 2007. Full text, available at: http://www.inl.gov/technicalpublications/Documents/4511504.pdf.

8. Hashemian, H. M. , “The state of the art in nuclear power plant instrumentation and control,” Int. J. Nuclear Energy Science and Technology, Vol. 4, No. 4, 2009, pages 330- 354.
9. U.S. DOE Office of Nuclear Energy, “ Nuclear Energy Research and Development Roadmap, Report to Congress,” April 2010 at http://nuclear.energy.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf )
10. U. S. Department of Energy, Fuel Cycle Research and Development Program. (URL: http://nuclear.energy.gov/fuelcycle/neFuelCycle.html)
    Idaho National Laboratory Advanced Test Reactor National Scientific User Facility: http://nuclear.inl.gov/atr/.
11. Idaho National Laboratory, “Technical Program Plan for the Next Generation Nuclear Plant/Advanced Gas Reactor Fuel Development and Qualification Program,” Rev. 3, INL/EXT-05-00465, August 2010.
12. Petti, D. et al., “The DOE Advanced Gas Reactor (AGR) Fuel Development and Qualification Program,” 2005 International Congress On Advances In Nuclear Power Plants, May 15-19, 2005, INEEL/CON-04-02416: http://www.inl.gov/technicalpublications/Documents/3169816.pdf.