US DOE SBIR/STTR
TECHNICAL TOPIC DESCRIPTIONS

OFFICE OF BASIC ENERGY SCIENCES

1. INSTRUMENTATION FOR NEUTRON SCATTERING, ELECTRON MICROSCOPY, AND SCANNING PROBE MICROSCOPY

The Department of Energy supports research and facilities in neutron scattering and electron and scanning probe microscopy areas for the characterization of materials.

Grant applications are sought only in the following subtopics:

a. Neutron Facilities—As a unique and increasingly utilized research tool, neutrons have made invaluable contributions to the physical, chemical, and biological sciences. The Department is committed to enhancing the operation and instrumentation of its present and future neutron science facilities so that their full potential is realized.

Grant applications are sought to develop improved neutron detectors and associated electronics needed for DOE's existing and proposed steady-state and pulsed neutron scattering facilities (References 1-3). New detectors must represent substantial improvements in one or more of the following parameters: efficiency at short wavelengths, high counting rate capability, high spatial resolution in one or two dimensions, time resolution (for pulsed source applications), cost per unit area, and adaptability to unique geometries. Detectors for pulsed neutron applications must be able to identify the time of arrival of each neutron. All detectors must have low intrinsic dark count rates and low sensitivity to gamma radiation.

Grant applications are sought to develop novel or improved neutron optical components for use in neutron scattering instruments (References 4-6). Such components include, but are not limited to, neutron choppers, neutron guides, neutron lenses and focusing mirrors, neutron monochromators, neutron polarization devices including ^{3}He polarizing filters, radio-frequency flippers, superconducting coils, and Meissner shields. Grant applications also are sought for novel uses of such components in neutron scattering instruments.

Grant applications also are sought to develop novel or improved sample environments (Reference 7), including extreme temperature, pressure, magnetic field, and chemical environments. Specific areas of interest include robotics for sample exchange and alignment, and equipment automation and data management systems to facilitate high throughput experiments at high flux sources.

Finally, grant applications are sought to develop virtual neutron scattering instruments utilizing a web portal based interface with access to high performance computing (HPC), grid, and/or cluster computing resources. Portal applications should enable users to configure virtual instruments to simulate experiment measurements and may include interfaces with materials simulations to provide a broader, more comprehensive range of sample scattering responses.

Questions - contact Lane Wilson (Lane.Wilson@science.doe.gov)

b. Electron Microscopy and Scanning Probe Microscopy (SPM)—The enabling component of nanoscience, recognized in workshop reports sponsored by National Nanotechnology Initiative and by the Department of Energy, is the capability to image, manipulate, and control matter and energy on nanometer, molecular, and ultimately atomic levels. Electron and scanning probe microscopies are vital to the advancement of materials science, nanoscience, and nanotechnology, and are used in numerous research projects and facilities funded by the Department. Innovative instrumentation developments offer the promise of radically improving the capabilities of electron and scanning probe microscopies, thereby stimulating new innovations in materials science. Grant applications are sought to develop:

- Stages, holders, and/or detectors with new capabilities for quantifying data and collection efficiency in electron beam instruments. Areas of interest include: (1) extremely stable holders and stages that allow long exposure/analysis times, with accurate tilting and alignment capability (to an angle accuracy ±0.005 degrees on two axes, while maintaining eucentricity to within 20 nm); (2) fast CCD camera systems that allow electron imaging exposure times in the millisecond range and kHz frame rates; (3) cameras optimized for handling femto-second electron pulses with MHz repetition rate; (4) high sensitivity electron imaging systems based on CCD technology, which provide 24 bit dynamic range or better over large areas; and (5) X-ray detectors employing drift technology base upon material of higher atomic number (i.e. for example Ge rather than Si), to increase the high energy detection capability. Proposed approaches for electron detectors must show suitability for either low- or high-energy electrons, and address one or more of the following three aspects: high quantum efficiency, high spatial resolution, and high temporal resolution. Proposed approaches for x-ray detectors should show significant improvement in sensitivity or spectral resolution for elemental analysis in electron microscopes.

- Stages and holders with new capabilities for *in situ* experiments or sample manipulation in the electron microscope. Stages and/or holders must provide for one or more of the following: (1) stable (low drift) stages that have electrical connections for up to 5 signals (minimum of two independent signal circuits), can be tilted at least 60 degrees in the electron microscope, and can be operated from 10K- 373K; (2) manipulation or measurement of the sample using a 4-probe nanomanipulator, including the capability to measure deflection or strain, or the capability to apply electric fields or current; and (3) stages that enable different types of *in situ* science, such as behavior in liquid and/or gaseous environments (30 Torr or higher). Also of interest are: stages that allow precision alignment of samples to an angle accuracy of ±0.005 degrees on two axes; or stages that allow the application of a magnetic field up to 5000 Oe, with a capability to rotate the field orientation in the specimen plane with respect to the sample.

- New electron sources that can operate from pulsed modes to femtosecond frequencies. Of particular interest are laser-assisted field emission guns for application to pulsed mode operation in Transmission Electron Microscopy (TEM) mode.

- Systems for automated data collection, processing, and quantification. Systems should include hardware and platform-independent software for data collection and visualization, including automated measurement and mapping of crystallography, internal magnetic or electric field, or strain, and for multi-spectral analysis. Software and quantification routines for image reconstruction and for interpretation of interference patterns/holography are encouraged.

- New generations of functional SPM probes, sample holders/cells, and controller/software support for ultrafast, environmental and functional detection. Areas of interest include: (1) insulated and shielded probes for high-resolution electrical imaging in conductive solutions; (2) probes integrated with electro-optical switches for ultrafast imaging; and (3) probes integrated with electrical and magnetic field sensors, including field effect transistors, single electron transistors, and Hall probes for probing dynamic electrical and magnetic phenomena in the 10 MHz – 100 GHz regime. Complementary to this

effort is the development of reliable hardware, software, and calibration methods for the vertical, lateral, and longitudinal spring constants of the levers, sensitivities, and frequency-dependent transfer functions of the probes.

- A new generation of optical detectors for beam-deflection-based force microscopies. Areas of interest include: (1) low-noise laser sources and detectors approaching the thermomechanical noise limit, (2) high bandwidth optical detectors operating in the 10-100 MHz regime, and (3) small-spot (sub - 3 micron) laser sources for video-rate Atomic Force Microscopy (AFM) measurements.

- Systems for next-generation controllers and stand-alone modules for data acquisition and analysis beyond currently employed homodyne and phase-locked loop detectors. Areas of interest include: (1) multiple-frequency detection schemes for mapping energy dissipation, as well as mechanical and other functional properties, (2) active control of tip trajectory, and (3) single event detection in molecular systems.

Grant applications submitted to this subtopic must address improvements in electron beam and scanning probe instrumentation capabilities beyond the present state of the art.

Questions - contact Jane Zhu (Jane.Zhu@science.doe.gov)

Subtopic a References:

1 Anderson, I. S. and Guerard, B., eds., Advances in Neutron Scattering Instrumentation, San Diego, CA, July 7-8, 2002, Proceedings of the SPIE (International Society for Optical Engineering), Vol. 4785, Bellingham, WA: SPIE, 2002. (ISBN: 0-8194-45525)

2 Cooper, R., et al., eds., "A Program for Neutron Detector Research and Development," White Paper based on workshop held July 2002. (Full report available at: http://www.sns.gov/pubs/detector_research_white_paper_mar03.pdf)

3 Wilpert, T., ed., "International Workshop on Position-Sensitive Neutron Detectors: Status and Perspectives," Hahn-Meitner-Institute, Germany, June 28-30, 2001. (Full report is available at: www.hmi.de/bensc/psnd2001. On menu at left, click on "Abstracts and Slide Reports")

4 Majkrzak C. F. and Wood, J. L., eds., Neutron Optical Devices and Applications, San Diego, CA, July 22-24, 1992, Proceedings of the SPIE, Vol. 1738, Bellingham, WA: SPIE, 1992. (ISBN: 0-8194-09111)

5 Mezei, F., et al., eds., Neutron Spin Echo Spectroscopy, Lecture Notes in Physics, 601, New York, Springer Verlag, 2003. (ISBN: 3-5404-42936).

6 Klose, et al., eds., "Proceedings of the Fifth International Workshop on Polarized Neutrons in Condensed Matter Investigations," Washington, D.C., June 1-4, 2004, *Physica B: Condensed Matter*, Vol. 356, Elsevier, 2004. (ISSN: 0921-4526)

7 Crow, J., et al., "SENSE: Sample Environments for Neutron Scattering Experiments," Tallahassee, FL, September 24-26, 2003, Workshop Report, 2004. (Full report available at: http://neutrons.ornl.gov/workshops/tallahassee_workshops_2003/presentations/Meissner.pdf)

Subtopic b References:

1 "Proceedings of the Microscopy Society of America," Annual Meetings, Springer-Verlag, New York, Inc. (ISSN: 1431-9276)

2 "Ultramicroscopy," 78(1-4), Elsevier-Holland, June 1999. (ISSN: 0304-3991)

3 Williams, D. B. and Carter, C. B., Transmission Electron Microscopy: A Textbook for Materials Science, Vols. 1-4, Plenum Publishing Corp., New York-London, 1996. (ISBN: 0-3064-52472)

4 "Aberration Correction in Electron Microscopy: Materials Research in an Aberration-Free Environment," Argonne National Laboratory, July 18-20, 2000, Workshop Report, U.S. DOE Argonne National Laboratory, October 2001. (Full report available at: http://ncem.lbl.gov/team/TEAM%20Report%202000.pdf)

5 BES-Sponsored workshop reports that address the current status and possible future directions of some important research areas are available on the web. (URL: http://www.science.doe.gov/bes/reports/list.html)

6 "Nanoscience Research for Energy Needs," Report of the National Nanotechnology Initiative Grand Challenge Workshop, March 16-18, 2004 (https://public.ornl.gov/conf/nanosummit2004/energy_needs.pdf)

7 Morita, S. (Ed.), "Roadmap of Scanning Probe Microscopy," (Series: NanoScience and Technology) Springer, 2006 (ISBN: 9-7835-40343-141)

8 S. Kalinin and A. Gruverman, "Scanning Probe Microscopy (2 vol. set): Electrical and Electromechanical Phenomena at the Nanoscale," Springer, 2006. (ISBN-10: 0-3872-86675) (ISBN-13: 9-7803-87286-679)

2. TECHNOLOGY TO SUPPORT BES USER FACILITIES

The Office of Basic Energy Sciences, within the DOE's Office of Science, is also responsible for other current and future user facilities including synchrotron radiation, free electron lasers, and the Spallation Neutron Source (SNS). This topic seeks the development of technology to support these user facilities.

Grant applications are sought only in the following subtopics:

a. Synchroton Radiation Facilities – As synchrotron radiation has become a ubiquitous tool across a broad area of forefront science, the DOE supports collaborative research centers for synchrotron radiation science. Research is needed for advanced detectors and advanced radiation sources, including superconducting and short-period undulators.

With advances in the brightness of synchrotron radiation sources, a wide gap has developed between the ability of these sources to deliver high photon fluxes and the ability of detectors to measure the resulting photon, electron, or ion signals. At the same time, advances in microelectronics engineering should make it possible to increase data rates by orders of magnitude, and to increase energy and spatial resolution. With the development of fourth-generation x-ray sources with femtosecond pulse durations, there will be a need for detectors with sub-picosecond time resolution. Therefore, grant applications are sought to develop new detectors for synchrotron radiation science across a broad range of applications. Areas of interest include: (1) area detectors for diffraction experiments; (2) area detectors for readout of electron and ion signals; (3) detectors capable of

ultra-high temporal resolution; (4) high resolution imaging detectors; (5) detectors for high rate fluorescence spectroscopy; and (6) detectors for high energy fluorescence spectroscopy.

For medium energy (2-3 GeV) synchrotrons, superconducting undulators (SCU's), with with short periods (around 1.5 cm) and high-peak magnetic fields (around 1.6 tesla), are required to generate tunable, monochromatic x-ray beams in the 2 - 30 keV photon energy range. Although development efforts are underway at several National Laboratories and in industry to develop such SCUs, the permanent magnets, commonly used in the undulators do not produce sufficiently high magnetic fields to fully cover the desired photon energy range without gaps in the spectrum. The current designs suffer from an inability to operate without quenching in the presence of the heat induced by the stored electron beam current and by synchrotron radiation encountered in modern synchrotron light sources – this heat load can be up to 100 watts per meter of undulator length. Grant application are sought to develop novel concepts for SCU design, construction, and thermal management, in order to meet these challenging requirements.

For low energy electron beams (1-2 GeV), undulators are required with periods shorter than that generally available on existing synchrotron radiation sources. Grant applications are sought to develop short wavelength (approximately 1 nm) undulators with period < 1 cm, K-value ~1, impedance shielding of pole faces, and a gap greater than 2.25 mm.

Questions – contact Roger Klaffky (Roger.Klaffky@science.doe.gov)

b. Beam Diagnostic Instrumentation for Free Electron Lasers and 3rd Generation Light Sources – Advanced electron-beam diagnostic instruments are needed to support the development of X-ray Free Electron Lasers (FEL), as well as the operation and upgrade of 3rd generation light sources.

Grant applications are sought to develop monitors for beam position and electron bunch length. The beam position monitor should have sub-micron resolution and associated electronics for both linac and storage ring applications. The electron beam bunch length monitor should perform non-destructive measurements, be capable of single-bunch resolution better than 100 fs, and possess a system design that is relevant for the bunch parameters of the future X-ray FEL and 3rd generation light sources.

Grant applications also are sought to develop diagnostics devices for the non-destructive measurement of electron beam emittance and for the energy spread within electron bunches. For FEL applications, measurements of electron bunch properties require resolution on the order of 10 μm, so that the so-called "slice" properties can be determined with sufficient accuracy. Both the beam emittance and the energy spread of the beam are critical parameters in FELs, and the measurement techniques must allow for rapid and non-invasive tuning, as well as for the implementation of feedback systems for systems optimization. Approaches of interest include optical techniques that employ transition radiation or synchrotron radiation. The diagnostics should be small (< 1 m length scale) and suitable for integration into an operational light source.

Grant applications also are sought to develop diagnostics for the measurement of charge modulation within an electron bunch at optical wavelengths in the regime 50-1000 nm. Seeded FELs utilize an inverse FEL scheme to first introduce an energy modulation into an electron bunch; then a dispersive transport region converts the energy modulation into a charge density modulation along the electron bunch. The charge density is modulated with the same period as the laser, i.e., in the wavelength regime 50-1000 nm.

Finally, grant applications are sought to develop a diagnostic technique for the dynamic measurement of the transverse position of the centroid of an electron bunch, as a function of position along that bunch. The transverse wakefields in a linac may introduce the so-called "banana shape" beam as a result of the beam-break-up instability, in which deflecting wakefields introduce a transverse spatial offset in the electron distribution

along a bunch. Proposed diagnostics must be able to measure this effect with spatial resolution on the order of 1 μm, and with temporal resolution (along the bunch) of 10-100 fs, in bunches of peak current 10-500 A.

Questions – contact Roger Klaffky (Roger.Klaffky@science.doe.gov)

c. High Power Mercury Spallation Targets – Technology is needed to mitigate cavitation damage erosion (CDE) in short-pulse liquid-mercury spallation targets. CDE has the potential to limit the power capacity and lifetime of targets. Damage has been observed inside test target vessels irradiated with small numbers of intense proton beam pulses; also, this damage has been studied at length in out-of-beam experiments that mimic the driving mechanism of cavitation. The damage is caused by intense and abrupt pressure waves that are induced by the near instantaneous heating of the mercury by the proton beam. Although certain surface hardening processes have shown promise in resisting damage, their potential to greatly enhance power capacity is believed to be limited. Therefore, grant applications are sought to develop:

(1) Small gas bubbles to reduce beam-induced pressure. A population of small gas bubbles introduced in the mercury could absorb and attenuate the beam-induced pressure sufficiently to halt the driving mechanism for cavitation. The desired bubble size is approximately 10 μm in diameter and the required void fraction approaches 1%. Grant applications are sought to develop: (1) techniques for generating this population of bubbles in mercury; and (2) credible diagnostics to quantify the generated population.

(2) Protective gas layers. Mercury, with its highly non-wetting characteristic and high surface tension is well-suited to the formation and stabilization of large gas pockets. Therefore, one promising option for damage mitigation involves the creation of an interstitial gas layer between the liquid metal and the containment vessel wall. Grant applications are sought to develop innovative gas/liquid flow concepts for utilizing gas layers to protect pressure-vessel surfaces from damage due to the cavitation of flowing mercury. Approaches of interest include: (1) the use of radiation-hard solid materials, such as metallic porous media or screens, as separate structures that are not part of the pressure boundary; (2) extensive surface modifications, such as grooves or cross-hatching to increase surface area, or (3) other geometries designed to trap gas permanently at the desired location. Because the most vulnerable pressure boundary surfaces in the SNS target are vertical, proposed solutions must address the problem of blanketing (protecting) vertical surfaces, where the hydrostatic gradient tends to force the gas to rise.

(3) Alternative and innovative concepts for damage mitigation**.** Grant applications also are sought for concepts for damage mitigation aside from small gas bubbles or protective gas walls. Proposals must demonstrate an awareness of spallation target design and environmental requirements, with respect to high radiation and mercury compatibility.

Questions – contact Roger Klaffky (Roger.Klaffky@science.doe.gov)

d. Instrumentation for Ultrafast X-ray Science – The Department of Energy seeks to advance ultrafast science dealing with physical phenomena that occur in the range of one-trillionth of a second (one picosecond) to less than one-quadrillionth of a second (one femtosecond). The physical phenomena motivating this subtopic include the direct observation of the formation and breaking of chemical bonds, and structural rearrangements in both isolated molecules and the condensed phase. These phenomena are typically probed using extremely short pulses of laser light. Ultrafast technology also would be applicable in other fields, including atomic and molecular physics, chemistry and chemical biology, coherent control of chemical reactions, materials sciences, magnetic- and electric field phenomena, optics, and laser engineering.

Grant applications are sought to develop and improve laser-driven, table-top x-ray sources and critical component technologies suitable for ultrafast characterization of transient structures of energized molecules

undergoing dissociation, isomerization, or intramolecular energy redistribution. The x-ray sources may be based on, for example, high-harmonic generation to create bursts of x-rays on subfemtosecond time scales, laser-driven Thomson scattering and betatron emission, and laser-driven K-shell emission. Approaches of interest include: (1) high-average-power ultrafast sources that achieve the state-of-the-art in short-pulse duration, phase stabilization and coherence, and high duty cycle; (2) driving lasers that operate at wavelengths longer than typical in current CPA titanium sapphire laser systems; and (3) characterization and control technologies capable of measuring and controlling the intensity, temporal, spectral, and phase characteristics of these ultrashort x-ray pulses.

Questions – contact Michael Casassa (Michael.Casassa@science.doe.gov)

Subtopic a References:

1 Thompson, A., et al., "A Program in Detector Development for the U.S. Synchrotron Radiation Community," White paper based on Workshop in Washington, DC, October 30-31, 2000. (Full text available at: http://www-esg.lbl.gov/Conferences%20&%20Meetings/detectorsync/DetectorSyncWhitePaper0801.pdf)

2 "PSD6-The Sixth International Conference on Position Sensitive Detectors," Leicester, UK, September 9-13, 2002, *Nuclear Instruments & Methods in Physics Research*, Section A–Accelerators, Spectrometers, Detectors and Associated Equipment, 477(1-3), January 21, 2002. (ISSN: 0168-9002) (Abstracts of papers and ordering information available at: http://www.sciencedirect.com/ Conference Programme available at http://www.src.le.ac.uk/psd6conference2002/)

3 Warwick, T, et al, eds., "Synchrotron Radiation Instrumentation: Eighth International Conference on Synchrotron Radiation Instrumentation," San Francisco, CA, August 25-29, 2003, American Institute of Physics, 2004. (AIP Conference Proceedings No. 705) (ISBN: 0-7354-01802) (Abstracts of papers and ordering information are available at: American Institute of Physics Conference Proceedings sub-series: *Accelerators, Beams, Instrumentation* at: http://proceedings.aip.org/proceedings/accelerators.jsp Search using Proceedings No. above.)

4 European Synchrotron Radiation Facility (ESRF) Workshop on "New Science with New Detectors," Grenoble, France, February 9-10, 2005. (Abstracts and presentation slides available at: http://www.esrf.eu/events/conferences/past-conferences-and-workshops/NewDetectors/)

5 ESRF Seventh International Workshop on "Radiation-Imaging Detectors (IWORID-7)," Grenoble, France, July 4-7, 2005. (Workshop Final Programme (with abstracts) currently available at: http://www.esrf.eu/events/conferences/past-conferences-and-workshops/IWORID7/)

6 Proceedings of the SPIE (International Society for Optical Engineering): "Optics and Photonics 2005: Ultrafast X-ray Detectors and Applications II," San Diego, CA, July 31- August 4, 2005, Vol. 5920, Bellingham, WA: SPIE, 2005. (ISBN: 08194-59259) (Table of Contents available at: http://spie.org/app/Publications/ Search by Volume number.)

Subtopic b References:

1. Fiorito, R. B., "Optical Diffraction-Transition Radiation Interferometry Beam Divergence Diagnostics," Presented at the 12th Beam Instrumentation Workshop, Batavia, IL, May 1– 4, 2006. (Presentation slides available at: http://conferences.fnal.gov/biw06/tuesday_talks/TAMC0101_talk.ppt)

2. Roehrs, M., et al., "Time-Resolved Measurements Using a Transversely Deflecting RF-Structure," Presented at 37th ICFA Advanced Beam Dynamics Workshop on Future Light Sources, Hamburg, Germany, May 15-19, 2006 . (Abstract available at: http://adweb.desy.de/mpy/FLS2006/abstract_booklet.pdf Scroll down to title.)

3. Loos, H., "Instrumentation for Linac-Based X-ray FELs," Presented at the 12th Beam Instrumentation Workshop, Batavia , IL , May 1– 4, 2006. (Presentation slides available at: http://conferences.fnal.gov/biw06/wednesday_talks/WAMI0202_talk.ppt)

4. Schmüser, P., et al., "Single-Shot Longitudinal Diagnostics with THz Radiation," Presented at 37th ICFA Advanced Beam Dynamics Workshop on Future Light Sources, Hamburg, Germany, May 15-19, 2006. (Full text available at: http://adweb.desy.de/mpy/FLS2006/proceedings/PAPERS/WG512.PDF)

5. Beutner, B., et al., "Beam Dynamics Experiments and Analysis in FLASH on CSR and Space Charge Effects," Presented at 37th ICFA Advanced Beam Dynamics Workshop on Future Light Sources, Hamburg, Germany, May 15-19, 2006. (Abstract and presentation slides available at: http://adweb.desy.de/mpy/FLS2006/proceedings/HTML/AUTH0055.HTM)

6. Smith, G. and Russo, T., "Proceedings of 10th Beam Instrumentation Workshop (BIW 2002)," Upton, New York, May 2002, American Institute of Physics (AIP), 2002. (ISBN: 0-7354-01039) (AIP conference Proceedings 648) (Table of contents and ordering information available at: http://proceedings.aip.org/proceedings/confproceed/648.jsp)

Subtopic c References:

1. Haines, J. R., et al., "Summary of Cavitation Erosion Investigations for the SNS (Spallation Neutron Source) Mercury Target," *Journal of Nuclear Materials*, 343: 58-69, 2005. (ISSN: 0022-3115)

2. Futakawa, M., et al., "Pitting Damage by Pressure Waves in a Mercury Target," *Journal of Nuclear Materials*, 343: 70-80, 2005. (ISSN: 0022-3115)

3. Riemer, B. W., et al., "SNS Target Tests at the LANSCE-WNR in 2001, Part I," *Journal of Nuclear Materials*, 318: 92-101, 2003. (ISSN: 0022-3115)

4. Wendel, M. W., et al., "Experiments and Simulations with Large Gas Bubbles in Mercury Towards Establishing a Gas Layer to Mitigate Cavitation Damage," Proceedings of FEDSM-2006: 2006 ASME Joint U.S. European Fluids Engineering Summer Meeting, Miami, Florida, July 17-20, 2006. (Paper No. FEDSM2006-98222) (Abstract and ordering information available at: http://store.asme.org/category.asp?catalog%5Fname=Conference+Papers&category%5Fname=Fluids+Engineering%A0&Page=1 Click on title at 2nd bullet. Search for 98222.)

Subtopic d References:

1 "The Science and Applications of Ultrafast, Ultraintense Lasers (SAUUL): Opportunities in Science and Technology Using the Brightest Light Known to Man," Report on the SAUUL workshop sponsored by DOE and NSF, 2002. (Full text available at: http://www.er.doe.gov/bes/chm/Publications/SAUUL_report_final.pdf)

2 "National Task Force on High Energy Density Physics, Frontiers for Discovery in High Energy Density Physics," U.S. DOE Office of Science and Technology Policy, July 2004. (Full text available at: http://www.ofes.fusion.doe.gov/News/HEDPReport.pdf)

3 Kapteyn, H. C., et al., "Extreme Nonlinear Optics: Coherent X-Rays from Lasers," *Physics Today*, 58: 39, 2005. (Full text available at: http://scitation.aip.org/journals/doc/PHTOAD-ft/vol_58/iss_3/39_1.shtml)

4 Phuoc, K. T., et al., "Laser-Based Synchrotron Radiation," Physics of Plasmas, 12: 023101, January 2005. (Full text available at: http://loa.ensta.fr/pxf/Articles/pop_2005.pdf)

5 Jiang, Y., et al., "Generation of Ultrashort Hard-X-ray Pulses with Tabletop Laser Systems at a 2-kHz Repetition Rate," *Journal of the Optical Society of America*, B20: 229 – 237, 2003. (http://josab.osa.org/abstract.cfm?id=70903)

6 Seres, J., et al., "Source of Coherent Kiloelectronvolt X-Rays," *Nature*, 433: 596, 2005. (ISSN: 0028-0836)

7 Zhang , X. et al, "Quasi-Phase-Matching and Quantum-Path Control of High-Harmonic Generation Using Counterpropagating Light," *Nature Physics*, 3: 270 – 275 (2007) (Abstract Available at http://www.nature.com/nphys/journal/v3/n4/abs/nphys541.html)

8 "Controlling the Quantum World: The Science of Atoms, Molecules, and Photons," Committee on AMO 2010, National Research Council, National Academy of Science, 2007. (Full text available at: http://www.nap.edu/catalog/11705.html)

3. ACCELERATOR TECHNOLOGIES FOR PRESENT AND FUTURE ACCELERATOR FACILITIES

The development of improved accelerator technology is the foundation on which the Office of Basic Energy Sciences facilities are upgraded and new facilities built.

Grant applications are sought only in the following subtopics:

a. Accelerator Modeling and Control—Grant applications are sought to develop new or improved computational tools for the design, study, or operation of charged particle beams. Of particular interest is the development of a front-end design for user-friendly interfaces. The modeling challenges addressed must be relevant to present and future BES accelerator facilities. These challenges include, but are not limited to, beam halo generation and control; generation and synchronization of sub-ps x-ray pulses; wakefield computation; multiple and single bunch collective instabilities; electron cloud generation and effects, especially in high-intensity proton rings; and high-intensity operation (beam losses, thermal effects, etc.)
Grant applications also are sought to investigate and develop enhancements to the suite of tools in the Experimental Physics and Industrial Control System (EPICS), in order to better support existing facilities and meet the requirements of future machines. Areas of interest include, but are not limited to, high-availability alternative-communication protocols; enhanced functionality within the Input-Output Controller; highly integrated development environments; and ensuring scalability to very large installations (such as the International Linear Collider). Grant applications should address how the results will guide long-term EPICS development.
Finally, as the time scale of interest in modern accelerators is reduced, the required computational resources are becoming prohibitive for currently-available low-order electromagnetic codes; for example, the estimated

memory requirement for modeling a typical accelerator structure interacting with a 1-ps bunch is 1 TB. Such an extreme computation is intractable for most accelerator laboratories. Therefore, in order to break the computational bottleneck, grant applications are sought to develop computational electromagnetic codes with high-order accuracy.

Questions - contact Roger Klaffky (roger.klaffky@science.doe.gov)

b. Radio Frequency (RF) Devices and Components—With respect to high level RF accelerator systems, grant applications are sought to develop:

(1) A high-level amplitude and phase modulator (in either waveguide or coaxial topology) that can demonstrate modulation ability out to 20 kHz. Significant cost savings could be achieved if one klystron were used to drive multiple accelerating cavities, while retaining phase and amplitude control at the individual cavity level.
(2) A variable input coupler for normal conducting (NC) and superconducting (SC) RF cavities. Approaches must demonstrate a significant increase in mechanical complexity compared with fixed coupler designs, and provide for adjustments of the input coupler beta *in situ*, in order to optimize the RF system efficiency.
(3) A high-efficiency-switching high-voltage power supply for next generation RF accelerator systems, which will need cleaner HV DC power on RF amplifier devices, in order to create less phase and amplitude jitter on the RF output. Regulation of line power ripple must be achieved at the 0.5% level.
(4) Higher order mode (HOM) inductive output tube (IOT) continuous wave (CW) amplifiers at 350 MHz (tunable over a reasonable range would be desirable) at two power levels: 1 MW CW (applicable to the case where one amplifier drives several cavities) and 200 kW CW (in the case where each cavity has its own amplifier). Such a device could provide lower operating voltage, smaller size, and lower operating cost (approximately 15-20% higher efficiency over current klystrons). The potential energy cost savings with an IOT that could operate at ~70% efficiency (television IOTs approach that now with depressed collectors) would be significant. Making the IOTs tunable over a reasonable range also would be a desirable feature.
(5) Pulsed inductive output tube (IOT) amplifier at 402.5 MHz, 140 kW, 10% duty factor for low-energy bunching application for high power H-/proton beams.
(6) A very high power (60-80 kW) solid state power amplifier to replace klystron amplifiers in synchrotron light sources.
(7) HOM damped superconducting RF cavities to be used as accelerating cavities at 500 MHz and/or as a bunch lengthening cavities at 1500 MHz.
(8) A 1KHz. 300 kV, 300A solid-state modulator for production of pico-second X-ray pulses using RF deflecting cavities.
(9) Development of higher power Integrated Gate Bipolar Transistor (IGBT) technology. IGBTs with > 6000Volts, >2000Amps are required for development of high power modulators and power supplies.
(10) Development of robust high average power (200kW) 1kHz modulator system. System to operate at about 300 kV, 300 A with ultimate rep rate at 1kHz or higher.
(11) Development of a high power fundamental power coupler (FPC) for ERL injector cavities with the following specifications: 1408 MHz operating frequency, average RF power up to 200 kW in traveling waver (TW) mode, nominal external Q of 5 x $10^{4,}$ factor of 10 variable coupling with minimum transverse kick to the beam.

With respect to low level RF[LLRF] accelerator systems, grant applications are sought to develop:

(1) An RF phase detector that can provide accurate measurements of phase jitter down to 0.01°, which is needed at several accelerator facilities (e.g., the Linear Coherent Light Source and for future ultra-

short x-ray capabilities at the Advanced Photon Source) and can provide an independent accurate measurement of the LLRF control performance. When the accelerator beam itself is used to determine RF system performance, facility commissioning is difficult.

(2) A user-friendly, multi-channel "all in one" time-stamp diagnostic instrument that can accept base-band RF signals out to 3 GHz, as well as DC signals, for analysis of RF accelerator system fault events. Accurate and timely fault analysis is necessary for present and future user facilities to operate at a very high level of reliability, and an "all-in-one" box would be more efficient than using several individual scopes.

Grant applications also are sought to develop devices for the manipulation of electron beams in storage rings and linear accelerators. Such devices are used to facilitate deflection of the beam onto a predicted trajectory or to generate a time-space correlation in the beam. For example, electromagnetic (RF) cavities operating in a dipole mode could introduce a transverse kick to an electron bunch as a whole or provide a "head-tail" displacement within the bunch. Such cavities would need to provide deflecting kick voltages up 10 MV, with phase error $< 0.01°$ and amplitude error $<10^{-4}$, with parasitic modes damped to Q-values <1000 and with minimal short-range wakefields.

Finally, grant applications are sought to develop new or improved acceleration schemes for linac-driven synchrotron radiation sources. Designs should provide high gradient (10-100 MVm^{-1}) in CW mode, with high efficiency wall-plug-to-beam-power conversion. Systems should be capable of supporting up to 500 mA beam current, with parasitic mode Q-values below 1000, and with minimal short-range wakefields.

Questions - contact Roger Klaffky (roger.klaffky@science.doe.gov)

c. Superconducting Technology for Accelerators—Complete 476 MHz superconducting RF systems are needed for present and future storage ring applications. Grant applications are sought to develop:

(1) A single-cell 476 MHz superconducting RF cavity that can support 2A CW operation, provide more than 2 MW energy gain with field gradient excess of more than 10 MV/m, and have a loaded Q higher than 10^8 at 4.5 k.
(2) An RF power coupler capable of handling 500 kW cw RF power.
(3) Digital, low-level RF systems to control the phase and amplitude of superconducting RF cavities operating at 476 MHz, with loaded Q-values in the range of 10^8. Of particular interest are systems capable of phase control at the level 2^o or better, and amplitude control at the level of 1% or better.

In addition, with the successful implementation of superconducting radiofrequency accelerating structures at facilities in all regions of the world, additional emphasis is being placed on reducing superconducting radiofrequency (SRF) cryomodule costs and improving manufacturing quality. Therefore, grant applications are sought for innovative concepts and design approaches to the manufacture of cryomodule assemblies containing multiple-processed SRF cavities. Approaches of interest include new cavity cooling and support systems, reliable cavity tuners and tuner components, and less expensive fundamental couple assemblies. Finally, a fundamental conceptual issue has arisen concerning the cooling of superconducting linacs during high-power pulsed operation. At fast pulse (1 ms), high-average forward-power levels (~ 75 kW), excessive thermal radiation loads from the fundamental couplers result in high couple surface temperatures, which reduce cavity stability and operating accelerating gradients. Therefore, grant applications are sought to develop innovative cooling concepts for fundamental power couplers, which do not impact the performance of the associated superconducting cavities.

Questions - contact Roger Klaffky (roger.klaffky@science.doe.gov)

d. Advanced Sources for Accelerators—Grant applications are sought to develop novel electron gun features including:

(1) Robust materials suitable for production of low emittance electron bunches at high repetition rate using laser excitation. Intrinsic normalized emittance of the electron beam must be of order 10^{-7} m-mrad, in bunches of order 100 pC charge, duration of approximately 10 ps, and with quantum efficiency of 10^{-2} or greater. Materials should be robust to environmental conditions, have small dark current under applied electric fields of order 10-100 MVm^{-1}, and have long lifetime.
(2) High power laser oscillator systems for high repetition rate (1-100 MHz) electron guns that can deliver pulses of 10-100 μJ energy in the 1 μm wavelength range, with pulses capable of being expanded to10-50 ps duration.
(3) Accelerating structures supporting electric fields of 10-100 MVm^{-1} at a cathode surface, allowing laser excitation of the cathode material and rapid acceleration of the emitted electrons with minimal emittance growth, and having an electron bunch repetition rate of 1 MHz or greater. Combined with suitable cathode materials and a photocathode laser, the system should be capable of producing low emittance (less than 1 mm-mrad normalized) electron bunches at a minimum 1 MHz repetition rate, with up to 1 nC charge per bunch.

In addition, grant applications are sought to develop high-current, high brightness sources of negative hydrogen ions. The goal is the production of ~70 mA of H- with a normalized emittance of 0.2 ·πmm·mrad, or about 100 mA, with a normalized emittance of 0.35 ·πmm·mrad. These currents and emittances have to be achieved for 1 ms long pulses at 60 Hz. The current should remain constant within ~5%. The lifetime as well as the mean-time-between-failure should exceed several weeks. Of special interests are highly efficient ionization technologies that can produce such beams with moderate power levels (< 40 kW peak power).
Finally, advanced undulator radiation sources are required for current and future light sources.

Grant applications are sought for the development of:

(1) Superconducting undulators (SCUs) that can generate tunable, monochromatic x-ray beams in the 2-30 keV photon energy range from medium-energy (2-3 GeV) synchrotrons. These requirements demand that the undulators have a short period (around 1.5 cm) and high peak magnetic fields (around 1.6 tesla). The permanent-magnets commonly used in undulators do not produce sufficiently high magnetic fields to fully cover the desired photon energy range without gaps in the spectrum. Development efforts are underway at several National Laboratories and in industry to develop SCUs that promise to overcome these deficiencies. However, current designs suffer from an inability to operate without quenching in the presence of the heat induced by the stored electron beam current and by synchrotron radiation encountered in modern synchrotron light sources. This heat load can be up to 100 watts per meter of undulator length. Novel ideas for SCU design, construction, and thermal management are needed to meet these challenging requirements.
(2) Undulators with period < 1 cm. The resonant condition for undulator radiation at short wavelength (approximately 1 nm), with low energy electron beams (of 1-2 GeV), requires undulators with period that is shorter than generally available on existing synchrotron radiation sources. Undulator designs are sought with K-value ~1, impedance shielding of pole faces, and a gap of greater than 2.25 mm.

Questions - contact Roger Klaffky (roger.klaffky@science.doe.gov)

Subtopic a References:

1 Bisognano, J. J. and Mondelli, A. A., eds., Computational Accelerator Physics, Williamsburg, VA, September 24-27, 1996, American Institute of Physics (AIP), May 1997. (AIP Conference Proceedings No.

391) (ISBN: 1-56396-671-9)

2 Qiang, J. and Ryne, R., "Parallel Beam Dynamics Simulation of Linear Accelerators," *Proceedings of ACES 2002: 18th Annual Review of Progress in Applied Computational Electromagnetics*, Monterey, CA, March 18-22, 2002, January 31, 2002. (Report No. LBNL-49550) (Full text available at: http://www.osti.gov/energycitations/servlets/purl/792968-2qDC1P/native/792968.pdf)

3 Ko, K., "High Performance Computing in Accelerator Physics," Proceedings of 18th Annual Review of Progress in Applied Computational Electromagnetics: ACES-2002, Monterey, CA, March 18-22, 2002. (Full text available at: http://www-group.slac.stanford.edu/acd/Computers2.html#)

4 Ryne R., et al., "SciDAC Advances and Applications in Computational Beam Dynamics," presented at SciDAC (Scientific Discovery Through Advanced Computing) 2005, San Francisco, June 26-30, 2005. (Full text available at: http://seesar.lbl.gov/anag/publications/colella/LBNL-58243.pdf)

5 Proceedings of ICAP 2004--the International Computational Accelerator Physics Conference: St. Petersburg, Russia, June 2004, "Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment," 58(1), March 2006. (Abstracts and ordering information for papers available at: http://sciencedirect.com. One menu at left, Browse by journal title, above; then by volume and issue.)

6 Proceedings of EPICS (Experimental Physics and Industrial Control System) Collaboration Meeting, Argonne, IL, June 2006. (Presentation slides available at: http://www.aps.anl.gov/News/Conferences/2006/EPICS/index.html. On menu at left click on "Presentations." To view slides, click on titles.)

Subtopic b References:

1. Proceedings of Fourth CW and High Average Power RF Workshop, Argonne National Laboratory, Argonne, IL, May 1-4, 2006 . (Abstracts and presentation slides available at: (http://www.aps.anl.gov/News/Conferences/2006/CWHAP06/index.html)

2. Proceedings of Low Level RF (Radio Frequency) Workshop, CERN, October 2005. (Abstracts and presentation slides available at: http://ab-ws-llrf05.web.cern.ch/ab-ws-llrf05/. On menu at left, click on "Conference programme and registration" and then on author index. Click on titles next to authors' names to view abstracts. For slides, click on "slides".)

3. Kneisel, P., "Latest Developments in Superconducting RF Structures for Beta=1 Particle Acceleration," Proceedings of EPAC06, (European Particle Accelerator Conference), Edinburgh, June 2006. (Full text available at: http://accelconf.web.cern.ch/AccelConf/e06/Pre-Press/WEXPA01.pdf)

4. Hosoyama K., et al., "Crab Cavity Development," (Full text available at: http://www.lns.cornell.edu/public/SRF2005/pdfs/ThA09.pdf)

Subtopic c References:

1. Schneider, W. J., et al., "Design of the SNS Cryomodule," Proceedings of the 2001 Particle Accelerator Conference, Chicago, IL, June 2001. (Full text available at: http://www.jlab.org/. On menu at left click on "Publications." Click on "Research Publications Submission and Search Database." Search by article title.)

2. Campisi, I. E., "State of the Art Power Couplers for Superconducting RF Cavities," EPAC 2002, Paris, June 2002. (Full text available at: http://accelconf.web.cern.ch/AccelConf/e02/TALKS/TUXGB002.pdf)

3. Stirbet, M., et al., "High Power RF Tests on Fundamental Power Couplers for the SNS Project," EPAC 2002, Paris, June 2002. (Full text available at: http://accelconf.web.cern.ch/AccelConf/e02/PAPERS/THPDO016.pdf)

4. Padamsee, H., et al., "RF Superconductivity for Accelerators," New York, Wiley & Sons, 1998. (ISBN: 0471154326)

5. "PEP II Cavities for the SPEAR 3 Upgrade," ACCEL Instruments GmbH Website. (URL: http://www.accel.de/pages/pep2_cavities_for_spear3.html)

Subtopic d References:

1. Ben-Zvi, I. , "Ampere Average Current Photoinjector and Energy Recovery Linac," presented at FEL 2004, Trieste, Italy, Aug. 29- Sept. 4, 2004. (Full text available at: http://accelconf.web.cern.ch/AccelConf/f04/. Search by author.)

2. Proceedings of the Future Light Source Workshop (FLS2006), Hamburg, Germany, May 2006. (Full text available at: http://adweb.desy.de/mpy/FLS2006/proceedings/index.htm)

3. Stockli, M., "The Development of High-Current and High Duty-Factor H- Injectors," presented at LINAC'06, Knoxville, TN, August 2006. (Available from author by email request. Email: stockli@ornl.gov)

4. Casalbuoni, S., et al., "Generation of X-Ray Radiation in a Storage Ring by a Superconductive Cold-Bore In-Vacuum Undulator," *Physical Review Special Topics: Accelerators and Beams*, 9(1), January 2006. (ISSN: 1098-4402) (Full text available at: http://prst-ab.aps.org/onecol/PRSTAB/v9/i1/e010702)

5. Bernhard, A., et al., "Planar and Planar Helical Superconductive Undulators for Storage Rings: State of the Art," Proceedings of EPAC 2004, Lucerne, Switzerland, July 2004. (Full text available at: http://accelconf.web.cern.ch/AccelConf/e04/PAPERS/MOPKF025.PDF)

6. T. Hara et al., "Cryogenic Permanent Magnet Undulators," *Physical Review Special Topics: Accelerators and Beams*, 7(5), May 2004. (ISSN: 1098-4402) (Full text available at: http://prst-ab.aps.org/pdf/PRSTAB/v7/i5/e050702)

4. ADVANCED COAL RESEARCH

For the foreseeable future, the energy needed to reduce our dependence on imported foreign oil and sustain economic growth will continue to come largely from fossil fuels. However, in supplying this energy need, the Nation must address growing global and regional environmental concerns, supply issues, and energy prices. Maintaining low-cost energy in the face of growing demand, diminishing supply, and increasing environmental pressure requires new technologies and diversified energy supplies. These technologies must allow the Nation to use all of its indigenous resources more wisely, cleanly, and efficiently. These resources include the Nation's most abundant and lowest cost resource, coal.

Grant applications are sought only in the following subtopics:

a. Coal and Biomass-to-Liquids (CBTL) Catalyst Development—As oil prices continue to rise, the production of fuels from sources such as biomass or coal once again appear attractive. Feedstocks composed of mixed biomass and coal could result in neutral or negative carbon emissions, reducing the impact on global warming. In particular, fuels produced from Fischer-Tropsch synthesis (FTS) are premium products with low aromaticity, zero sulfur, and high energy content, resulting in ultra-clean transportation fuels with minimum tailpipe emissions. In this process, catalysts are used to hasten CO hydrogenation reactions for the desired products; avoid wide varieties of competing reactions; lower the temperature and pressure; maintain activity and selectivity in stable operation for long periods of time; and in some cases, accelerate the water gas reaction.

Bio-catalysis also may find application in the conversion of syngas to fuels. A preliminary evaluation indicated that microorganisms could produce alcohols (up to C3), acetic/propionic acid, and acetone from syngas. For some strains, the preliminary results showed slow CO conversion (40%) to alcohols, predominately ethanol. The current emphasis has shifted towards maximizing the yield of high-cetane (C10-C20) products from Fischer-Tropsch synthesis.

Grant applications are sought for novel and innovative catalytic improvements that could contribute significantly to more economical manufacturing of synthetic liquid fuels from coal/biomass-derived syngas. One possible approach involves the development of catalysts with higher selectivity to molecular species, which would be useful in the production of high performance fuels. For hydrocarbons, this means conversion (preferably in one step) to high octane gasoline components, diesel fractions, or olefins, which in turn can be converted to liquid fuels. For oxygenates, this means the production of octane-enhancing ethanol or higher mixed alcohols. Other approaches of interest include: (1) catalysts that eliminate or greatly reduce methane formation, particularly in FT processes or in higher alcohol manufacture; (2) catalysts that provide for operation of process modes, which are engineered to improve plant investment and operating costs (e.g., a catalytic slurry system that can control heat release and decrease the requirements for syngas recycle); (3) catalysts with higher stability, thereby providing resistance to attrition or to deactivation by carbon deposition, sulfur, or halides; and (4) catalyst systems capable of providing better efficiency through process integration.

Proposed approaches must be novel and innovative, and show clear economic advantages over the existing state of the art.

Questions - contact Doug Archer (douglas.archer@hq.doe.gov)

b. Development of New and Novel CO_2 Monitoring Devices/Sensor for Detection of Low Levels of CO_2 in the Surface and Subsurface—Carbon sequestration has emerged as a key potential technology pathway for the reduction of greenhouse gas emissions associated with fossil fuel power plants. Because potential reservoir leakage paths are not known, monitoring will be required over large areas above and around the reservoirs. In addition, many of the injection sites could be miles from the power plant, requiring miles of above-ground or buried pipe. The relative background levels of CO_2 present in the atmosphere and soil make detection of small levels of CO_2 leaks difficult. Therefore, grant applications are sought to accelerate the development of low-cost sensors for the detection of low levels of CO_2 in the surface and subsurface. Proposed approaches must: (1) address the practical problem of deployment, (2) address practical and low cost methods to monitoring and maintain the sensors along the CO_2 stream and reservoir, (3) address risk, safety, and economic considerations with respect to the type of geological sequestration reservoirs, and (4) recommend at least one candidate site for viability of commercial-scale testing of the sensors and sensor arrays by industry.

Questions – contact Regis Conrad (regis.conrad@hq.doe.gov)

c. Sealing Systems for High Temperature Solid Oxide Fuel Cells—High temperature (650C to 850C) solid oxide fuel cell (SOFC) stacks involve the formation of alternating fuel and air chambers, which are sealed from each other and connected to gas flow delivery manifolds. The planar walls of the chambers are the cells and interconnect plates. A common stack configuration utilizes the material at the edges of the plates to define the gas delivery path from one cell to the next. While specific proprietary stack geometries accomplish gas flow management in unique ways, they all require seals that maintain the separation of the air and fuel along the various joints of the planar configuration.
Grant applications are sought to develop new concepts for SOFC seal systems. The sealing procedure must be consistent with the manufacturing steps during stack assembly, and with the thermal and mechanical variations that are present during initial start-up. Also, degradation resistance during thermal transients would be a beneficial feature of a robust seal system (despite the fact that there are relatively fewer and more benign thermal cycles in coal syn-gas power plant applications compared to other applications). Other sealing system requirements include appropriate mechanical strength, reliability, gas tightness, and compatibility with the other functional and structural parts of the SOFC stack. The seal material must exhibit appropriate interfacial chemical stability in contact with mating parts and must not emit gas contaminant species that would poison the electrochemically active electrode surfaces. Lastly, grant applications should provide the complete context for appropriate seal configuration and testing.

It is impossible to describe in detail, in this limited space, the complexities of a SOFC seal system relevant to functional state-of-the-art stacks being developed as an element of a power plant. Examples of seal systems currently being developed can be found in the SECA web site under the proceedings of the SECA Core Technology Program workshops (http://www.netl.doe.gov/technologies/coalpower/fuelcells/seca/workshop.html, http://www.netl.doe.gov/publications/proceedings/06/seca/index.htm). The SOFC group at Pacific Northwest National Laboratory (PNNL) is presently constructing short stack test vehicles that encapsulate the environmental boundary conditions that would be placed on a candidate seal system. Potential applicants can obtain more detail regarding the short stack configuration by contacting Dr. Prabhakar Singh (Prabhakar.Singh@pnl.gov (509-375-5945).

Questions - contact Ayyakkannu Manivannan (Ayyakkannu.Manivannan@netl.doe.gov)

d. Advanced R&D in Coal-to-Liquids Technology Improvement—Commercial production of CTL (coal-to-liquids) fuels has been in operation in South Africa since the 1970s, with a current capacity of 150,000 barrels per day. [1] A recent publication indicates that the erection of a CTL plant in U.S. would be feasible under the right circumstances. [2] CTL technology includes a coal gasification step to produce syngas (mainly carbon monoxide and hydrogen), followed by a second step to remove impurities and then by the syngas conversion step to produce liquid hydrocarbon fuels. The last step is known as Fischer-Tropsch (F-T) synthesis, which employs catalysts to facilitate the syngas conversions.

In F-T synthesis, the reactor is preceded with a guard bed to remove the trace impurities left in the feed stream exiting the syngas cleanup step. This is considered a "must" arrangement in order to maintain the robust performance of F-T catalysts. The current technology uses zinc oxide as the sorbent, which is most effective in the temperature range of 800 – 1200°F range. [4] However, these sorbents are not effective at temperatures representative of warm syngas cleanup [3], an emerging technology that can contribute to a more efficient system integration of the three steps in the CTL process.

Grant applications are sought for novel sorbents that can match the exit temperature (300-700°F) from the warm gas cleanup step. The new sorbents must be able to remove nearly all the trace impurities left in the gas feed to F-T reactor, including sulfur, halides, mercury, and arsenic. Grant applications must demonstrate familiarity with: (1) the advanced warm syngas cleanup R&D underway, (2) the contamination mechanisms of F-T

catalysts by the trace impurities in coal-derived syngas, (3) analytic techniques needed to analyze the trace impurities at very low levels, and (4) published data in the literature with respect to sorbent developments for other gas cleanup applications.

Questions – contact John Shen (john.shen@hq.doe.gov)

Subtopic a References:

1 Hydrogen & Clean Fuels Research, U.S. Dept. of Energy, Office of Fossil Energy, Office of Sequestration, Hydrogen & Clean Coal Fuels. (Available at: http://www.fe.doe.gov/programs/fuels/index.html)

2 Samuel, P., "GTL Technology – Challenges and Opportunities in Catalysis," Central Fuel Research Institute, Dhanbad – 828108, *Bulletin of the Catalysis Society of India* 2 (2003) 82-99. (Full Text Available at http://203.199.213.48/183/1/254_P._Samuel.pdf)

3 Benham, C.B. & Bohn, M.S., "Maximization of Diesel Fuel Production from an Iron-Based Fischer-Tropsch Catalyst," Rentech, Inc., AIChE Spring National Meeting, Houston, TX, March 14-18, 1999. (URL: http://www.rentechinc.com/dieselfuel.htm)

4 Nikolopoulos, A.A., Gangwal, S.K., and Spivey, J.J., "Effect of Periodic Pulsed Operation on Product Selectivity in Fischer-Tropsch Synthesis on Co-ZrO2/SiO2,", in Studies in Surface Science and Catalysis 136: Natural Gas Conversion VI (E. Iglesia, J.J. Spivey, and T.H. Fleisch, eds., Elsevier Science) (2001) 351. (ISBN-10: 0-4445-22212) (ISBN-13: 9-7804-44522-214)

5 Ma, W., Kugler, E.L., Wright, J., Dadyburjor, D.B., "Effect of Molybdenum Loading on Iron-Based Fischer-Tropsch Catalyst," AIChE Annual Meeting, Cincinnati, OH, October 30, 2005. (Summary Available: http://aiche.confex.com/aiche/2005/techprogram/P15849.HTM)

6 Fischer-Tropsch Synthesis, Catalysts and Catalysis, eds., Davis, B.H., CAER, U.Ky., Lexington, KY., Occelli, M.L., MLO Consultants, Atlanta, GA., series ed., Centi, G., Studies in Surface Science and Catalysis, Vol. 163, Elsevier, 2007. (ISBN-10: 0-4445-22212) (ISBN-13: 9-7804-44522-214)

7 Agrawal, R., Singh, N.R., Ribeiro, F.H., Delgass, W.N., "Sustainable Fuel for the Transportation Sector," *PNAS*, vol. 104, no. 12, March 20, 2007. (Available at www.pnas.org/cgi/doi/10.1073/pnas.0609921104)

Subtopic b References:

1. Benson S & Myer L. "Monitoring to Ensure Safe and Effective Geologic Sequestration of Carbon Dioxide", in IPCC workshop on carbon dioxide capture and storage, Regina, 2002. (Full text available at: http://arch.rivm.nl/env/int/ipcc/docs/css2002/ccs02-10.pdf)

2. Wildenborg A. Scheffers B, Ribberink H and Schrover A, 2002, "Framework for the Safety and Monitoring of a Facility for Underground CO_2 Sequestration", Netherlands Institute of Applied Geoscience TNO – National Geological Survey, Utecht, 28. (Full text available at: http://www.senternovem.nl/mmfiles/26245_tcm24-124147.pdf)

3. "Carbon Sequestration Technology Roadmap and Program Plan-2005," U.S. DOE Office of Fossil Energy/National Energy Technology Laboratory, May 2005. (Full text available at: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/2007/2007Roadmap.pdf)

4. Gale J and Davison D., "Transmission of CO_2: safety and economic considerations", Sixth International Conference on Greenhouse Gas Control Technologies Kyoto, Japan, vol 1. Gale J and Kaya Y, editors. Amsterdam: Pergamon, 2003. p. 517-522 (http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V2S-4CB63P9-5&_user=10&_coverDate=08%2F31%2F2004&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=2cb18243a076922e34186d22179ef36b)

Subtopic c References:

1 Minh, N. Q. and Takahashi, T., Science and Technology of Ceramic Fuel Cells, Amsterdam, NE: Elsevier, 1995. (ISBN-10: 0-444-89568) (ISBN-13: 9-7804-44895-684)

2 Solid State Energy Conversion Alliance Website. (URL: http://www.seca.doe.gov/)

3 Bouwmeester, H. J. and Gellings, P. J., CRC Handbook of Solid State Electrochemistry, Boca Raton, CRC Press, 1997. (ISBN: 0-8493-89569)

4 7th Annual **SECA** Workshop and Peer Review, September 12-14, 2006. (Available at: http://www.netl.doe.gov/publications/proceedings/06/seca/index.htm)

5 Fergus, J.W., "Sealants for Solid Oxide Fuel Cells," *Journal of Power Sources*, 147, 46-57 (2005). (http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TH1-4GBD7XV-8&_user=10&_coverDate=09%2F09%2F2005&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=2c04217765dd672d57fa776c8cfeaeb2)

6 R.K. Brow, "Thermochemically Stable Sealing Materials for Solid Oxide Fuel Cells," Solid State Energy Conversion Alliance 6th P Annual Workshop, Pacific Grove, CA, Apr. 18-21, 2005. (INVITED) (Full text available at: http://www.netl.doe.gov/publications/proceedings/05/SECA_Workshop/pdf/day2_3/UMR-Brow%204-20.pdf)

Subtopic d References:

1 Sichinga, J., "Coal-to-liquids: a business view", paper presented at the EFI Members Conference, Charleston, SC, Feb. 6 -9, 2005 (Available at: http://goliath.ecnext.com/coms2/gi_0199-4311515/Coal-to-liquids.html)

2 "Baseline technical and economic assessment of a commercial scale Fischer-Tropsch liquids facility", DOE/NETL-2007/1260, April 9, 2007 (Full text is available at: http://www.netl.doe.gov/energy-analyses/pubs/Baseline%20Technical%20and%20Economic%20Assessment%20of%20a%20Commercial%20S.pdf)

3 "Gasification – Gas Cleaning & Conditioning", National Energy Technology Laboratory Website. (URL: http://www.netl.doe.gov/technologies/coalpower/gasification/gas-clean/index.html)

4 US Patent 5494880 (URL: http://www.patentstorm.us/patents/5494880.html)

5. MATERIALS FOR ADVANCED NUCLEAR ENERGY SYSTEMS

The Generation IV nuclear energy initiative is an international collaboration to identify, assess, and develop sustainable nuclear energy technologies that are competitive in most markets, while further enhancing nuclear safety, minimizing the nuclear waste burden, and reducing the risk of proliferation (reference 1). Many nuclear energy systems have been proposed to advance the goals of the Generation IV program (see references 2-5), including designs that use liquid-metal coolants such as sodium and gas coolants such as helium. For these reactor concepts, operation at higher temperature has been identified as a means to improve economic performance and/or to support the thermochemical production of hydrogen. However, the move to higher operating temperatures will require the development and qualification of advanced materials to perform in the more challenging environment. As part of the process of developing advanced materials for these reactor concepts, a fundamental understanding of materials behavior must be established, and a database that defines the critical performance limitations of these materials under irradiation must be developed.

Grant applications are sought only in the following subtopics:

a. Advanced Radiation Resistant Ferritic-Martensitic Alloys and Oxide Dispersion Strengthened (ODS) Steels—Because of their resistance to void swelling, ferritic-martensitic and ODS steels are considered prime candidates for intermediate temperature applications, such as the proposed liquid metal reactor concept operating in the temperature range 400-750°C. However, many ferritic-martensitic steels are limited by poor higher temperature creep strength, typically degrading at temperatures greater than 550-600°C (reference 6), and ODS steels are difficult to form and weld. Grant applications are sought to improve the creep strength of ferritic-martensitic steels through alloying, dispersion strengthening, or precipitation hardening. Grant applications also are sought to improve the weldability and formability of ODS steels. Innovative alloys with protective coatings also are of interest. Proposed approaches must provide for: (1) isotropic creep properties with strength greater than that of Sandvik HT9 steel,
(2) a ductile-to-brittle transition temperature less than room temperature, and (3) a minimum plane-strain fracture toughness of $0.25\sigma_y$. Alloying elements that act as neutron poisons (e.g., boron) or that become highly activated in a neutron spectrum (e.g., cobalt) must be minimized or eliminated. Because the ferritic-martensitic and ODS steels likely would be used in conjunction with a sodium-cooled reactor concept, approaches that optimize corrosion performance while achieving improved high-temperature strength would be considered high priority. Lastly, approaches that also address irradiation performance are strongly encouraged.

Questions – contact Sue Lesica (sue.lesica@hq.doe.gov)

b. Advanced Refractory, Ceramic, Ceramic Composite, Graphitic or Coated Materials—Some Generation IV concepts aim for very high temperature (>900°C) operation. However, with the exception of limited data on SiC-based systems, the radiation resistance of construction materials subjected to very high temperatures has not been identified or proven. Grant applications are sought to develop advanced refractory, ceramic, ceramic composite, graphitic, or coated materials that can meet the very demanding conditions required to operate at temperatures greater than 900°C in a thermal spectrum nuclear energy system. For these conditions, the materials should have low thermal expansion coefficients, excellent high temperature strength, excellent high temperature creep resistance, and good thermal conductivity. For post-irradiation handling at lower temperatures, sufficient room temperature fracture toughness must be maintained. Additionally, the materials need to be easily fabricated and capable of being
joined. Because the reactors operating in this temperature regime are expected to be helium cooled, the materials must have low erosion properties in flowing helium and be able to survive an air ingress condition. Because the high temperature strength and corrosion resistance may be difficult to achieve with a single material, composite or coated systems may be required.

Questions – contact Sue Lesica (sue.lesica@hq.doe.gov)

References:

1 "Generation IV Nuclear Energy Systems," U.S. DOE Office of Nuclear Energy, Science and Technology Website. (URL: http://nuclear.energy.gov/genIV/neGenIV1.html)

2 "Global Nuclear Energy Partnership," U.S. DOE Office of Nuclear Energy, Science and Technology Website (URL: http://www.gnep.energy.gov)

3 Kiryushin, A. I. et al., "BN-800: Next Generation of Russian Sodium Fast Reactors," Proceedings of ICONE 10, ASME, 2002. (Paper No. 10-22405)*

4 Hittner, D., "The Renewal of HTR Development in Europe ," Proceedings of ICONE 10, ASME, 2002. (Paper No. 10-22423)*

5 King, R. L. and Porter, D. L., " Performance of Key Features of EBR-II (Experimental Breeder Reactor II) and the Implications for Next-Generation Systems," Proceedings of ICONE 10, ASME, 2002. (Paper No. 10-22524)*

6 Klueh, R. L. and Harries, D. L., "High Chromium Ferritic and Martensitic Steels for Nuclear Applications," West Conshohocken , PA: American Society for Testing and Materials, 2001. (ISBN: 0-8031-2090-7)

* Abstracts of papers and ordering information available through ASME
at:
http://store.asme.org/category.asp?catalog%5Fname=Conference+Papers&category%5Fname=Tenth+International+Conference+on+Nuclear+Engineering&Page=1.
Search by Paper No. in citation above.)

6. SOLID STATE ELECTROLYTE DEVELOPMENT FOR ADVANCED ENERGY STORAGE DEVICES

The projected doubling of world energy consumption within the next 50 years, coupled with the growing demand for low- or even zero-emission sources of energy, has brought increasing awareness of the need for efficient, clean, and renewable energy sources. In particular, the generation of electricity from renewable sources, such as solar or wind, offers enormous potential for meeting future energy demands. However, these sources are intermittent; therefore, an efficient electrical energy storage (EES) sytem is required to ensure that the electricity is reliably available 24 hours a day, as needed for commercial and residential grid applications. Even short fluctuations can cause changes in supply, which currently must be corrected using conventional power plants. Thus, for large-scale solar- or wind-based electrical generation to be practical, the development of new EES systems will be critical to making renewables dispatchable, meeting off-peak demands, shaving peak loads, and effectively leveling the variable nature of these energy sources.

The objective of this topic is to improve the performance and manufacturability of advanced utility-scale batteries, reduce their negative environmental effects, and ameliorate safety concerns. Improvements in battery performance rely as much on developments in electrolytes as they do on improvements in the active materials themselves. Most current battery cells all contain some form of liquid electrolyte. Often these electrolytes are toxic or flammable, and can cause a variety of problems should leaks occur. If solid state electrolytes could be

developed, many of these issues could be alleviated. Solid-state materials having high ionic conductivity (e.g., solid polymer electrolytes) have been the subject of extensive research for select electrochemical power sources for many years. The reasons for this are manifold: anticipated improvements in battery performance, enhanced geometric flexibility (size/shape), ease of manufacture (eg bipolar configurations), and improved safety. Nevertheless, these all-solid-state electrolytes still are not readily available for all battery chemistries.

Grant applications are sought only in the following subtopics:

a. Solid State Electrolyte Development for Lithium-Ion Chemistries—For lithium-ion rechargeable battery chemistries, lithium-ion-conducting materials will be needed as the electrolyte. Therefore, grant applications are sought to develop stable, safe, easy to manufacture, and cost effective solid-state electrolytes for lithium-ion transport for non-aqueous lithium-ion battery chemistries. Approaches leading to all-solid-state systems are preferred, with little (<0.5%) or no additional liquid content (e.g., no plasticizers or co-solvents). Electrolytes of interest must exhibit the requisite properties for use in these battery chemistries, including high room-temperature conductivity, chemical stability, electrochemical stability, thermal stability, and high transport number (ideally equal to 1; that is, a single ion conductor). Proposed solutions must be scalable to utility bulk energy storage systems.

Questions: contact Imre Gyuk (imre.gyuk@hq.doe.gov)

b. Solid State Electrolyte Development for Hydroxyl-Ion Transport in Aqueous Alkaline Chemistries— For alkaline based-systems such as nickel-metal hydride or nickel-cadmium batteries, hydroxyl-ion-conducting materials will be needed for the electrolyte. Therefore, grant applications are sought to develop stable, safe, easy to manufacture, and cost effective solid-state electrolytes for hydroxyl-ion transport for aqueous alkaline battery chemistries. Compared to lithium ion chemistries, higher quantities of water as plasticizer or co-solvent will be allowed. Nonetheless, all-solid-state systems, with little or no additional liquid phase, are preferred. Electrolytes of interest must exhibit proper electrochemical properties for these alkaline systems, including high room-temperature conductivity, chemical stability, electrochemical stability, and high transport number (again, a single ion conductor is preferred). Proposed solutions must be scalable to utility bulk energy storage systems.

Questions: contact Imre Gyuk (imre.gyuk@hq.doe.gov)

References

1 Alasdair M. Christie, et al., "Increasing the Conductivity of Crystalline Polymer Electrolytes", *Nature*, 433, 6 January 2005 (Text is for sale at http://www.nature.com/nature/journal/v433/n7021/fig_tab/nature03186_F1.html, click on the title)

2 Jennings, R.A., "Conducting Solids, Covering Ionic and Electronic Conductors", *Annu. Rep. Prog. Chem., Sect. A*, 1999, 95, 481-506 (ISSN 0260-1818)

3 Jorne, J. Lett, N., *Transference Number Approaching Unity in Nanocomposite Electrolytes*, Vol. 6, No. 12, 2006 (http://pubs.acs.org/cgi-bin/abstract.cgi/nalefd/2006/6/i12/abs/nl062182m.html)

4 Zheng, N, Bu, X., Feng, P., "Synthetic Design of Crystalline Inorganic Chalcogenides Exhibiting Fast-Ion Conductivity", *Nature*, 426, 27, 2003 (Text is for sale at http://www.nature.com/nature/journal/v426/n6965/fig_tab/nature02159_F1.html, click on title)

5 Tiyapiboonchaiya, C., et al., "The Zwitterion Effect in High-Conductivity Polyelectrolyte Materials"., *Nat. Materials*, 3, 29, 2004 (Text is for sale at http://www.nature.com/nmat/journal/v3/n1/suppinfo/nmat1044_S1.html, click on title)

6 Alarco, P.J., et al., "The Plastic-Crystalline Phase of Succinonitrile as a Universal Matrix for Solid-State Ionic Conductors," *Nat. Materials*, 3, 476, 2004 (Abstract available at: http://www.nature.com/nmat/journal/v3/n7/abs/nmat1158.html)

7. MATERIALS FOR ADVANCED COOLING APPLICATIONS

In U.S. residential and commercial buildings, space cooling (air conditioners) used about 3.4 Quads of primary energy in 2004, and refrigeration and freezers used about 2.3 Quads more. In the industrial sector, process cooling used about 0.7 Quads. And in the transport sector, air conditioning is a large load that constrains down-sizing of hybrid vehicle engines; overall, A/C accounts for roughly one-fifth of the power required by a mid-sized sedan traveling at 60 mph on a hot summer day. Combined, these various cooling requirements total roughly 7 Quads of primary energy per year.

Another problem concerns the adverse environmental impact of the refrigerant gas used in the mechanical vapor compression cycles of conventional air conditioners and refrigerators. Although the refrigerant gases used today are considered safe for the ozone layer (per the Montreal Protocol), they are strong greenhouse gases. Per molecule, the refrigerant R-134a used in vehicles, for example, has 1300 times the direct Global Warming Potential of carbon dioxide over a 100-year period. Current vehicular air conditioners leak 10 to 70 grams of R134-a year; the European Union (EU) requires that new model cars introduced in 2011, and all new cars by 2017, not use R134-a. There are also large refrigerant losses from residential and commercial air conditioners and refrigerators. According to the Intergovernmental Panel on Climate Change (IPCC) overall, these and other halocarbons contribute about 0.34 W/m^2 of radiative forcing, as of 2005, which is about one-fifth of that due to CO_2 alone, at 1.66 W/m^2.

The Department of Energy is seeking the development of advanced technologies for space cooling in buildings and vehicles, and for refrigeration in residential, commercial, and industrial applications. The new cooling technologies not only should be more energy efficient than current technologies but also should not use refrigerants that contribute to global warming. New technologies that might be successfully developed for advanced cooling applications include, but are not limited to, ThermoElectrics (TE), MagnetoCalorics, ElectroCalorics, and ThermoTunneling. Important contributory technologies also include advanced heat exchangers and advanced dehumidification technologies. These technologies also could allow systems to be reconfigured in advantageous ways. For example, vehicles cooling systems could be placed where most convenient, instead of being constrained to a position for belt-driven mechanical compression. Some of these technologies, particularly ThermoElectrics (TE), have long been used for cooling applications, but commercially available units typically have efficiencies of just one-fifth to one-tenth that of mechanical vapor compression cycles. Advances in TE materials offer the potential for raising these efficiencies significantly above those of conventional mechanical systems.

Approaches of interest should significantly reduce energy consumption compared to conventional mechanical vapor compression cycles and eliminate the use of refrigerants that provide a net contribution to global warming, while achieving costs at or below current levels for comparable systems. In addition, the new technologies should be lighter, more compact, and more durable than conventional refrigeration technologies. Grant applications must: (1) include a review of the state-of-the-art for both the technology application being targeted and the proposed technology; (2) address the potential public benefits that the proposed technology would provide; and (3) address the ease of implementation of the new technology. Phase I should include a preliminary design, along with a measurement of refrigeration cell performance. The measurement method

should be described and should be within the state of the art; however, as such measurements may be extremely difficult (as, for example, with nanoscale thermoelectrics), a test may be devised to verify the amount of cooling for a given level of power supplied.

Grant applications are sought only in the following topics.

a. Buildings Refrigeration and Air Conditioning—Conventional air conditioners, heat pumps and refrigerators, which collectively use 5.3 quads of energy in the U.S., achieve cooling through a mechanical vapor compression cycle (VCC). Although the efficiency of the best VCC systems is on the order of 40–45% of Carnot efficiency, these efficiency numbers may be approaching asymptotic values; hence, the opportunity for further improvement could be limited. Continuing progress in materials and manufacturing techniques may make advanced cooling technologies more attractive for building applications. Grant applications are sought to develop improved materials and manufacturing techniques that have the potential to provide improved cost-vs-performance compared to conventional VCC technologies. Proposed concepts may address a particular segment of this broad application area (e.g., commercial refrigeration). In addition, technologies of interest must: (1) have the potential for very high reliability; (2) be amenable to installation without reliance on skill sets not commonly available in most communities; and (3) offer significantly improved efficiency while avoiding refrigerants with climate change impacts.

Questions – contact Sam Baldwin (Sam.Baldwin@ee.doe.gov)

b. Vehicular Air Conditioning—Grant applications are sought to develop new vehicular air conditioning systems that not only can provide improved energy efficiency and avoid refrigerants with net greenhouse gas impacts, but also can withstand the accelerations, vibrations, and temperature excursions typically experienced in vehicle use in the U.S. The vehicle's Heating, Ventilation and Air Conditioning (HVAC) system should be able to provide a nominal cabin temperature less than 70^{o}F with a worst case ambient temperature of 122^{o}F. Grant applications should demonstrate an understanding of the requirements of a vehicle OEM (Original Equipment Manufacturer) with respect to desired heating and cooling loads, installation space, and interface parameters for specific vehicles. The Phase I project should include the preparation of a road map with major milestones leading to a production model of a vehicular HVAC system; this road map would form the basis for a follow on program.

Questions – contact Sam Baldwin (Sam.Baldwin@ee.doe.gov)

c. Industrial Process Refrigeration—Grant applications are sought for the development and application of new materials and technology systems that exploit waste or secondary heat for use in industrial process refrigeration, yet do not use refrigerants that could impact climate change. "Industry" is taken here in the broadest sense, to cover manufacturing, food processing, and space cooling in large commercial applications. Grant applications must demonstrate that the proposed approach will have a lower price and higher performance than current adsorption chillers or other available technologies.

Questions – contact Sam Baldwin (Sam.Baldwin@ee.doe.gov)

d. Utility and Industrial Heat Exchangers—In electrical utilities and in many process industries, improved heat transfer by heat exchangers offers great potential for improving process energy efficiency. Therefore, grant applications are sought for innovative heat exchanger materials and systems that provide significant cost-effective improvements in efficiency. Approaches of interest include the development of improved materials of construction; improved heat transfer fluid materials, including nanostructured fluids; and improved heat

exchanger design. Grant applications must: (1) identify and characterize a target application; (2) analyze the potential benefits of the proposed new heat exchanger technology; and (3) account for issues related to heat exchanger costs, ease of retrofit and installation, and maintenance, in order to make the innovation commercially viable.

Questions – contact Sam Baldwin (Sam.Baldwin@ee.doe.gov)

References:
Thermoelectrics:

1 Fairbanks, J, "Thermoelectric Generators for Near-Term Automotive Applications and Beyond", Plenary Presentation , European Thermoelectric Conference '06, Cardiff, Wales, April 10-11, 2006 (Full Text available at: http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2006/session6/2006_deer_fairbanks.pdf)

2 Bell, Lon, "Role of Thermoelectrics in Vehicle Efficiency Increases", 11th Diesel Engine Emissions Reduction Conference, Chicago, Illinois, August 21-25, 2005 (Full text available at: http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2005/session6/2005_deer_bell.pdf)

3 Robert F., "Semiconductor Advance May Help Reclaim Energy From 'Lost' Heat", Science, 31 March 2006, V.311, p.1860 (Full text available at: http://www.sciencemag.org/cgi/content/summary/311/5769/1860a)

4 Jianlin Liu, "Thermoelectric Coolers and Power Generators Using Self-assembled Ge Quantum Dot Superlattices", University of California Energy Institute, September 2004 (Full text available at: http://repositories.cdlib.org/ucei/basic/FSE005/)

5 M. S. Dresselhaus, et. al., "Investigation of Low-Dimensional Thermoelectrics", (Full text is available at: http://www-rcf.usc.edu/~scronin/pubs/d888.pdf)

MagnetoCalorics:

1 K.A. Gschneider, Jr., V.K. Pecharsky, and A.O. Tsokol, "Recent developments in MagnetoCaloric Materials," Rep. Prog. Phys, V.68 (2005) 1479-1539 (Full text available at: http://www.iop.org/EJ/abstract/0034-4885/68/6/R04/)

2 C. Zimm, et al., "Description and Performance of a Near-Room Temperature Magnetic Refrigerator," Advances in Cryogenic Engineering, Editor: P. Kittel, Plenum Press, New York, 1998. (ISBN 0-3064-58071)

ElectroCalorics:

1 A.S. Mischenko, et al., "Giant Electrocaloric Effect in Thin-Film $PbZr_{0.95}Ti_{0.05}O_3$," *Science*, 3 March 2006, V.311, p.1270-1271. (Full text available at: http://www.sciencemag.org/cgi/reprint/311/5765/1270.pdf)

ThermoTunneling:

1 M. Savin, et al., "Efficient electronic Cooling in Heavily Doped Silicon by Quasi particle Tunneling", Applied Physics Letters, Vol.79, N.10, pp.1471-1473. (Full text available at: http://scitation.aip.org/getpdf/servlet/GetPDFServlet?filetype=pdf&id=APPLAB000079000010001471000001&idtype=cvips&prog=normal)

2 Yoshikazu Hishinuma, et al., "Measurements of cooling by room-temperature thermionic emission across a nanometer gap", *Journal of Applied Physics*, V.94, N.7, 1 October 2003, pp.4690-4696 (Full text available at: http://scitation.aip.org/getpdf/servlet/GetPDFServlet?filetype=pdf&id=JAPIAU000094000007004690000001&idtype=cvips&prog=normal)

Heat Exchangers:

1 W.Y. Saman and S. Alizadeh, "Modeling and Performance Analysis of a Cross-Flow Type Plate Heat Exchanger for Dehumidification/Cooling", Solar Energy, V.70, N.4, pp.361-372, 2001 (Full text is available at: http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6V50-42DP0X2-5-2G&_cdi=5772&_user=10&_orig=search&_coverDate=12%2F31%2F2001&_sk=999299995&view=c&wchp=dGLbVtb-zSkWA&md5=5ade5f8fa2848a8512e92f0f687d1769&ie=/sdarticle.pdf)

Dehumidification:

1 Brookhaven National Laboratory, "Independent control of Sensible and Latent Cooling", Research Report EP 87-15, June 1989 (URL: http://www.osti.gov/energycitations/basicsearch.jsp search by report number)

2 IPCC: Intergovernmental Panel on Climate Change, "Climate Change 2007: The Physical Science Basis", Eds. Susan Solomon, et al. 2007. (URL: http://www.ipcc.ch/index.html See the Technical Summary, page 32.)

8. SOLID-STATE LIGHTING

Today, solid-state lighting (SSL) products fall short of performance requirements needed to meet the complex demands of the general illumination market. The DOE, in collaboration with the Next Generation Lighting Industry Association (NGLIA), industry stakeholders, and other Federal Agencies, have developed and published a detailed understanding of many of the contributing "core" technologies that are thought to limit the attainment of the DOE's goals for solid-state lighting (SSL), particularly with respect to light emitting diodes (LEDs) and organic light emitting diodes (OLEDs). Subtopics a, b, and c are concerned with some of the highest priority research areas: (1) increasing the external quantum efficiency of LEDs and OLEDs, (2) improving thermal management and increasing device performance of high brightness LEDs, and (3) improving device life-times for LEDs and OLEDs. Due to the anticipated basic nature of proposed projects, the end product may be intellectual property that would be available for license to a third party or may support an existing business relationship with a manufacturing partner. In such cases, the grant application should provide details about the potential IP relationship.

Subtopic d is concerned with the application of solid-state lighting to photovoltaic (PV) devices (or other renewable resources) to yield off-grid SSL products or lighting products that are not powered by electricity supplied from the utility grid. For this subtopic, grant applications must include: (1) a detailed product

development plan that results in the introduction of a commercially viable product at the conclusion of Phase III (not supported by the DOE or by the SBIR program); (2) a clear description of how the preliminary concept feasibility proven in Phase I will lead to a more advanced product developed during Phase II and ultimately, in commercialization during Phase III; and (3) a detailed energy conservation comparison that quantitatively illustrates exactly how the proposed product will offer an energy efficient alternative to a product currently serving the general illumination market (within the U.S. buildings sector or on relevant properties). Preference will be given to commercialization plans that emphasize domestic manufacturing and/or use of domestic components and labor. Applications that fail to address all of the above criteria will not be considered for award.

Grant applications are sought only in the following subtopics.

a. External Quantum Efficiency Improvement for LEDs and OLEDs—Internal quantum efficiencies of both LEDs and OLEDs are increasing rapidly, to the point where out-coupling or External Quantum Efficiency (EQE) is thought to limit the near-term manufacture of practical devices with high device efficacies. Grant applications are sought to explore and demonstrate novel, practical, and manufacturable methods to increase the EQE of selected materials systems. The chosen system must already possess a demonstrated high Internal Quantum Efficiency (IQE), and the approach must seek to demonstrate a quantifiable increase in device efficiency. This increase must be demonstrated without compromise to any fundamental characteristic of the subject materials system or device architecture, such as emissive spectrum or IQE. Grant applications must: (1) succinctly describe the envisioned EQE increase, (2) demonstrate a clear understanding of the subject challenge, (3) include a detailed plan showing exactly how proof-of-principle will be made during Phase I, and (4) present an approach that is fundamentally viable. Grant applications that seek to simply evaluate and study the opportunity space associated with this area of research will not be considered for award, nor will grant applications concerned with photonic crystals or resonant cavities (which are examples of related work that previously has been explored). Only new approaches, which build upon prior research or represent a totally new research direction, will be considered.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

b. Thermal Management for High Brightness LEDs—High brightness (HB) LEDs, which have demonstrated promise for general illumination applications, are limited by how much heat can be conducted away from the chip and the package. Innovations in heat transfer strategies, or in the materials used for substrates or packaging, may provide chip and device designers an opportunity to create even more powerful devices, which operate at higher current levels without suffering catastrophic thermal failures. These innovations may include materials or films with high thermal capacity or high thermal transport, or structures with higher temperature tolerance. Grant applications must include: (1) a clear and concise explanation of the proposed innovation, (2) a detailed quantitative estimate of the likely increase in device performance if proof-of-principle is demonstrated in Phase I. Theoretical model predictions are acceptable as Phase I deliverables; however, grant applications concerned with the development of advanced thermal models are not of interest and will be declined.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

c. Lifetime Issues for LEDs and OLEDs—High brightness LEDs and OLEDs intended for SSL have limited lifetimes, particularly when operated at the high current densities required for general illumination applications. The technical reasons for the limited lifetimes are very different for LEDs and OLEDs. For HB phosphor conversion LEDs, thermal issues and phosphor degradation are the predominant mechanisms for device failure. For OLEDs, issues associated with contaminants and defects are thought to cause early failures. Grant

applications are sought to develop technology that will significantly and positively impact device lifetimes. Approaches of interest include the development of unique materials, device designs, or any other method for achieving significant improvements to practical device lifetimes. Also of interest is the development of advanced theoretical knowledge or computational models that could be used by other researchers to develop devices with improved performance. Grant applications must: (1) identify specific mechanisms that will result in desired device lifetime improvements without compromising efficacy or other performance metrics, and (2) include detailed lifetime estimates.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

d. Off-grid SSL Products—The unique, low voltage power requirements of LED devices would be an ideal match to leading photovoltaic (PV) devices that have exhibited similar advancements in market penetration and use. These two emerging technologies can be combined to create useful products that do not use electric power supplied by the US electric grid. The combination represents an ideal way to conserve power or to provide lighting service where grid power is not available, too costly to deliver, or of questionable reliability. Illumination devices that are not of sufficient efficiency to be considered for routine use in US buildings may serve DOE's energy conservation goals by providing service that is completely removed from the grid. While many useful products have already been introduced (i.e., architectural and walkway lighting), there is ample room for new, imaginative product ideas that remove loads from the grid by shifting power requirements to a renewable source. Therefore, grant applications are sought to develop novel products that use a combination of SSL and PV, wind, batteries, or other novel method of energy storage. Areas of interest include architectural façade lighting, remote outdoor lighting, signs, marine applications, security illumination, emergency or portable lighting, or any other niche application that takes advantage of the unique properties of any or all of these emerging technologies. Grant applications must: (1) demonstrate that proposed devices will be cost competitive with the designs they replace, and (2) provide a favorable life cycle cost comparison.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

References:

1. Hong, E, et al, *U.S. Lighting Market Characterization, Volume II: Energy Efficient Lighting Technology Options*, 2005, Navigant Consulting, Inc., Washington, DC (Full text available at: http://www.eere.energy.gov/buildings/info/documents/pdfs/ee_lightingvolII.pdf)

2. D.A. Steigerwald, J.C. Bhat, D. Collins, R.M. Fletcher and M.O. Holcomb, "Illumination With Solid State Lighting Technology", IEEE Journal Selected Topics In Quantum Electronics, Vol. 8 (2), p. 310 (2002).

3. Craine, S. and Halliday, D., "White LEDs for Lighting Remote Communities in Developing Countries," Solid State Lighting and Displays: Proceedings of SPIE, 4445:39-48, December 2001. (For ordering information and to view abstracts, see: http://spie.org/x1636.xml?search_text=4445&category=ProceedingsVolumes)

4. *Solid-State Lighting R&D Multi-Year Program Plan FY'08-FY'13,* 2007, Navigant Consulting, Inc., Washington, DC. (Full text available at: http://www.netl.doe.gov/ssl/publications/publications-techroadmaps.htm)

5. Schubert, E. F., *Light Emitting Diodes*, Cambridge University Press, 2003. (ISBN: 0-521-82330-7)

6. Zukauskas, A., et al., Introduction to Solid State Lighting, John Wiley and Sons, Inc., 2002. (ISBN: 0-471-21574-0)

7. Kafafi, et al, *Organic Electroluminescence*, Taylor & Francis Group. 2005, (ISBN-10 0-8194-5859-7).

9. CATALYSIS

About 90 percent of chemical manufacturing processes and more than 20 percent of all industrial products in the U.S. employ underlying catalytic steps. For petroleum refining, over 80 percent of the processes involve catalysis. Catalysis also plays a substantial role in the production of 30 of the top 50 U.S. commodity chemicals. Of the remaining 20, six more are made from raw materials produced catalytically. The energy use component in the production of the top 50 chemicals is significant – 5 quadrillion BTUs per year – 3 quadrillion BTUs per year for those with catalytic production routes. It has been estimated that if all the catalytic processes associated with petroleum refining and with chemical manufacture of the top 50 chemicals were raised to their maximum yields, total energy savings would exceed one quadrillion BTUs per year. More efficient chemical production, resulting from improvements to catalytic processes, would also contribute to significantly reduced carbon emissions. This topic seeks to accelerate the catalyst discovery and application process by identifying catalysts that have higher selectivities, can operate at modest temperatures and pressures, and contribute to a reduction in the number of unit operations. It is intended that R&D be conducted to overcome current limitations of selectivity and efficiency, leading to substantial energy savings, improved economic performance, enhanced utilization of feedstocks, and reduced requirements for materials of construction.

Grant applications must address the potential public benefits that the proposed technology would provide from: (1) reduced energy consumption; and (2) the reduction in materials consumption, water consumption, and/or toxicity/pollutant dispersion. Grant applications also should include a plan for introducing the new technology into the US chemical and petroleum refining industries (i.e., those using natural gas, natural gas liquids, and petroleum derivative feedstocks), in order to access capabilities for widespread technology dissemination.

Grant applications are sought only in the following subtopics:

a. Heterogeneous Catalysis—Catalytic reforming, catalytic cracking, hydrocracking, alkylation, isomerization, and the conversion of methanol into olefins are some of the most important industrial applications of heterogeneous catalysis, in chemical manufacturing and petroleum refining. For example, the synthesis of oxygenated compounds from hydrocarbons involves heterogeneous oxidation catalysis, the cracking of paraffins to olefins, and the subsequent direct or indirect addition of oxygen. In such processes, the direct addition of oxygen to olefins is exothermic, and, therefore, increased selectivity would provide energy savings from reduced hydrocarbon feedstock requirements. Indeed, the enhancement of oxidation selectivity represents the largest potential improvement of energy efficiency in the chemical industry (Parshall, 1994). Grant applications are sought for the research and development of technologies for improving the efficiency of industrial catalytic oxidations, reductions, and acid-base catalysis. Areas of particular interest are: (1) selective oxidation of petroleum feedstocks for commodity chemicals, thereby enhancing efficiency by reducing over-oxidation; (2) alkane activation for direct oxidation with molecular oxygen, e.g., in the conversion of methane to methanol; (3) heat integration of catalytic oxidations with other processes; (4) improvements in the syntheses or use of reactive intermediates; (5) new catalysts for commodity chemical reductions including ammonia synthesis from elemental gases, fuel and gas reforming catalysts, and cathodic catalysts for fuel cells – new ideas for fuel cell catalysts for oxygen activation are of particular interest; and (6) new and improved catalysts for petroleum cracking in a fluidized bed, as well as new heterogeneous catalysts for alkene/alkane alkylation.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

b. Homogeneous Catalysis—Isomerizations, hydrogenations, oxidations, polymerizations, and esterifications are just a few of the many commercial applications of homogeneous catalysis. The DOE has a long and respected history of support for the development of homogeneous catalysts used for polymer syntheses, as well as homogenous catalysts used for chemical synthesis from synthesis gas. Grant applications are sought for the development of new homogeneous catalysts for these applications, especially homogeneous catalysts that avoid the use of precious metals such as rhodium.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

c. Reactive Separations—The integration of catalysts with separation technologies – for example, reactive distillations and catalytic membranes – could lead to improvements in energy efficiency. However, the tendency of homogeneous catalysts to dissolve in reaction media limits catalyst stability (and therefore their use) when the homogeneous catalysts are fixed to a membrane. Grant applications are sought for research and development that will overcome the technical barriers to the use of catalysts in reactive separations technology.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

References:

1. *Technology Vision 2020: The U. S. Chemical Industry*, Washington, DC: American Chemical Society (ACS), 1996. (Full text available at: http://www.eere.energy.gov/industry/chemicals/pdfs/chem_vision.pdf. Also available from DOE EERE Information Center: 1-800-862-2086)

2. *Vision 2020 Catalysis [Workshop] Report*, 1997. (Full Report available at: http://www.ccrhq.org/vision/index/roadmaps/catrep.html)

3. *Vision 2020 Reaction Engineering Roadmap*, 2001. (Full text available at: http://www.eere.energy.gov/industry/chemicals/pdfs/reaction_roadmap.pdf)

4. *Vision 2020: Chemical Industry of the Future: Technology Roadmap for Materials*, August 2000. (Full text available at: http://www.eere.energy.gov/industry/chemicals/pdfs/materials_tech_roadmap.pdf)

5. *Vision 2020: Workshop Report on Alternative Media, Conditions and Raw Materials*, July 1999. (Full text available at: http://www.eere.energy.gov/industry/chemicals/pdfs/alternative_roadmap.pdf)

6. U.S. Department of Energy (DOE), 2000, *Chemical Industry of the Future, Energy and Environmental Profile of the U.S. Chemical Industry*, Office of Industrial Technologies, Washington, D.C., May 2000. (Full text available at: http://www.eere.energy.gov/industry/chemicals/pdfs/profile_chap1.pdf. To access any segment of document, click on "+" next to "Table of Contents" on "Bookmarks" section of page. Then click on title of segment of interest.)

7. *Energy and Environmental Profile of the U.S. Petroleum Refining Industry*, U.S. Department of Energy, Office of Industrial Technologies, December 1998. (Full text available at: http://www.eere.energy.gov/industry/petroleum_refining/pdfs/profile.pdf)

8. *Biobased Industrial Products: Research and Commercialization Priorities*, National Research Council Commission on Life Sciences, 2000. (Full text available at: http://books.nap.edu/books/0309053927/html/2.html#pagetop)

9. *Vision for Bioenergy and Biobased Products in the United States*, U.S. Biomass Research and Development Advisory Committee, October 2002. (Full text available at: http://www.climatevision.gov/sectors/electricpower/pdfs/bioenergy_vision.pdf).

10. *Roadmap for Biomass Technologies in the United States*, U.S. Biomass Research and Development Advisory Committee, December 2002. (Full text available at: http://www.brdisolutions.com/pdfs/FinalBiomassRoadmap.pdf)

11. *Developing and Promoting Biobased Products and Bioenergy: Report to the President of the United States in Response to Executive Order 13134*, U.S. DOE and U.S. Department of Agriculture, February 14, 2000. (Full text available at: http://www.brdisolutions.com/Site%20Docs/presidentsreport.pdf)

10. CHEMICAL REACTIONS AND SEPARATION PROCESSES FOR BIOREFINERY APPLICATIONS

Research is needed to address energy intensive chemical reactions and separation processes that will contribute to the success of the bio-refinery as a viable commercial alternative to the production of fuels and chemicals. As envisioned in the United States, bio-refineries will be an important source for the production of fuels and commodity chemicals on a large scale, primarily with feedstocks derived from cellulosic starting materials. Most of the commodity chemicals used in a biorefinery will be oxygenates, produced via both thermochemical and biocatalytic (enzymes) processes. Grant applications submitted in response to this topic must show how the proposed approach will contribute to an energy-efficient biorefinery and that the costs of processing will be comparable to processes that use petroleum or natural gas feedstocks.

Grant applications are sought only in the following subtopics.

a. New Chemical Catalysts and Biocatalysts—Grant applications are sought to develop new catalysts to promote energy savings in a biorefinery for the chemical and allied process industries. Grant applications may address either heterogeneous or homogeneous catalysts, and any energy intensive chemical processes, including oxidations, reductions, substitutions, and isomerizations. Of particular interest is the development of new chemical catalysts that derive their properties from the special characteristics of nano-scale materials, or from nano-scale functionality imparted to a material. Also of interest is the development of catalysts for use with new feedstock materials. Because a wealth of R&D has been conducted on new catalytic materials, especially involving nano-scale materials with new catalytic properties, grant applications should include a review of the pertinent patent and scientific literature.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

b. Process Intensification—Grant applications are sought to develop process intensification methodology for common chemical processes and bioprocesses used in a biorefinery, leading to lower process energy requirements or savings in feedstocks. For example, microchannel reactor technology can reduce the dilution volume needed for many chemical processes, thus reducing the energy requirements of separations. Microchannel reactor technology also can be used in the application of chemical catalysis with enhanced selectivity. For bioprocesses, process intensification methodology may reduce the water requirements, which would further reduce the energy requirements. Grant applications should include a review of pertinent scientific and patent literature.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

c. Alternative Reaction Media—Grant applications are sought to develop new reaction media for both chemical processes and bio-processes used in a biorefinery, leading to reductions in the energy requirements of processing. For example, the use of ionic liquids as reaction media may reduce the energy requirements of chemical processing by eliminating distillation steps – instead, separations could be accomplished by complexification or other means. For bio-processing, reaction media other than water may reduce energy requirements compared to water-based processes. Grant applications should address the potential energy savings in the biorefinery for the manufacture of commodity chemicals.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

d. Separation Processes to Reduce or Eliminate Distillations—Grant applications are sought for new separation processes to reduce or eliminate distillation in the manufacture of commodity chemicals, using typical feedstocks or bio-based feedstocks, in a biorefinery. Approaches may include the development of new membrane process technology, absorption, and alternative methods such as complexification. Of particular interest are separation technologies that could be applicable to the manufacture of more than one commodity chemical product. Grant applications should: (1) demonstrate how the proposed separation technology will save energy over that used for distillation; and (2) provide a review of the pertinent scientific and patent literature, in order to ensure that there is no duplication of current or previous R&D.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

References:

1 *Biomass Program*, U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www1.eere.energy.gov/biomass/)

2 *Office of the Biomass Program – Technical Plan Summary*, U.S. DOE Office of Energy Efficiency and Renewable Energy. (Full text available at: http://www1.eere.energy.gov/biomass/pdfs/mytpsummary_040804.pdf)

3 Biomass Information Resources, U.S. DOE Office of Energy Efficiency and Renewable Energy Webpage. (URL: http://search.nrel.gov/query.html?st=11&charset=utf-8&ws=0&style=eere&col=eren&qc=eren&qp=url%3Awww1.eere.energy.gov/biomass/&qt=plan)

4 *Vision2020 Focus Area: Ionic Liquids*, Vision2020 Chemical Industry Technical Partnership Webpage. (URL: http://www.chemicalvision2020.org/ionic_liquids.html)

5 *Vision2020 Focus Area: Advanced Separations*, Vision2020 Chemical Industry Technical Partnership Webpage. (URL: http://www.chemicalvision2020.org/separations.html)

6 *Vision2020 Thrust: Biomass to Energy from Forestry and/or Farming*, Vision2020 Chemical Industry Technical Partnership Webpage. (URL: http://www.chemicalvision2020.org/biomass.html)

7 *Area of Interest 2 – Process Intensification*, National Energy Technology Laboratory Funding Opportunity Announcement. (URL: http://www.grants.gov/search/search.do?oppId=8726&mode=VIEW. Scroll down to text under "Description" heading.)

8 *Vision2020: Reaction Engineering Roadmap*, American Institute of Chemical Engineers, 2001. (Full text available at: http://www.chemicalvision2020.org/pdfs/reaction_roadmap.pdf)

New Biocatalysts: Essential Tools for a Sustainable 21st Century Chemical Industry, Roadmap resulting from workshop of the same name, held November 16-18, 1999 in Palo Alto California, 2001. (Full text available at: http://www.chemicalvision2020.org/pdfs/biocatalysis.pdf

11. TECHNOLOGIES RELATED TO ENERGY STORAGE FOR HYBRID AND PLUG-IN HYBRID ELECTRIC VEHICLES

Energy storage technology (batteries and/or electrochemical capacitors) represents one of the critical barriers to the development and marketing of cost-competitive hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs). The energy storage requirements for these two types of vehicles are somewhat different:

- HEVs require energy storage devices that can deliver high power pulses. For HEV applications, the goal is to develop cells that provide peak power of 1000 W/kg or greater, have a cycle life of at least 300,000 shallow cycles, and have a calendar life of 15 years.

- PHEVs require devices that both store significant energy and can deliver high power pulses. PHEVs will require batteries that can deliver significant energy (several kWh) for several thousand discharge cycles from an almost full charge to a lower state of charge. It has been suggested that a PHEV battery would operate in a charge-depleting hybrid mode from about 90% of full charge to about 25% of full charge. Once the battery reaches this lower state of charge, it will function in a manner similar to the battery in an HEV and must be able to sustain 200,000 – 300,000 shallow cycles with a 15 year calendar life.

All of these devices must be able to accept high power recharging pulses from regenerative braking. For all systems, the materials to be utilized should be plentiful, have low cost (< $10/kg), be environmentally benign, and be easily recycled. Evaluation of the technology with regard to the above criteria should be performed in accordance with applicable U.S. Advanced Battery Consortium test procedures or Society of Automotive Engineers recommended practices (see references that follow). Grant applications must show how proposed innovations would result in significant advances in performance and cost reduction over state-of-the-art technologies.

Grant applications are sought only in the following subtopics:

a. Technologies that Result in Cells with Increased Energy Density—Grant applications are sought to increase the energy density and specific energy of HEV and PHEV batteries by developing technology that will "stabilize" the surface of a lithium metal electrode in a rechargeable system. The stabilization technology must allow the electrode to be deeply cycled at least a thousand times, without significant loss of active lithium and without the formation of lithium dendrites that might short the cell. Possible approaches to this stabilization might include adding a "coating" on the surface of the lithium or an "additive" to the electrolyte in contact with the lithium. The technical effort should focus on stabilizing the lithium surface under electrochemical cycling conditions that would be found in a vehicular battery. It should be noted that the energy density and specific energy required of a battery designed for a PHEV application are greater than those for an HEV. (The electrode must be able to charge and discharge at rates that are appropriate for a PHEV application.)

Grant applications must: (1) identify the nature of the electrochemical couple in which the electrode would be used (i.e., identify the positive electrode and electrolyte); (2) provide a theoretical basis for the research; (3)

address the probable cost of using the technology in vehicular batteries; (4) address the impact of the technology on all performance parameters and assure that other performance requirements (e.g., cost, cycle life, calendar life, or abuse tolerance) will not be compromised; and (5) propose a Phase I project to demonstrate the technology by cycling a lithium metal electrode in a laboratory cell (whereas in Phase II, the cycling would be demonstrated on a scale and under conditions appropriate to a vehicular battery). Grant applications dealing with lithium-ion systems or materials designed for use in a lithium-ion battery, or dealing with conductive polymer electrolytes designed to be used with a lithium metal electrode, are not of interest and will be declined.

Questions - contact James Barnes (james.barnes@ee.doe.gov)

b. Development of Separators for Lithium-Ion Cells with High Temperature Melt Integrity —One of the concerns associated with the use of lithium-ion batteries in HEVs and PHEVs is the possibility of an internal short-circuit caused by the shrinkage of the separator at high temperatures. This short-circuit mechanism has been postulated as follows: (1) the battery becomes hot, causing (2) the separator in the cells begins to melt and shrink, which (3) allows the electrodes to short circuit, leading to (4) the cell going into thermal and/or electrochemical runaway and exhibiting unacceptable behavior. Grant applications are sought to develop separators that will retain their integrity at temperatures of 200 degrees C or higher. Proposed materials must meet all of the requirements for a lithium-ion separator (thickness, porosity, cost, etc.) at room temperature. Grant applications must clearly define how "melt integrity" and other relevant properties will be evaluated and what performance will be expected in each area. Also, a Phase I project should be proposed in which "coupon" size samples (10 cm^2 or larger) of the new separator are prepared and evaluated . In Phase II, the material would be refined, fully characterized, and prepared in quantities sufficient to allow the production of at least 100 vehicle-size cells using automated production equipment. (The actual production of these cells is required under this development effort, but acceptance of the new separator for testing by a production company must be confirmed.)

Questions - contact James Barnes (james.barnes@ee.doe.gov)

c. Development of "High Voltage" Electrolytes for Use in Advanced Lithium-Ion Cells—Batteries in PHEVs should have increased energy density and specific energy relative to the batteries now being used in HEVs. For a lithium-ion cell, one approach to increasing these parameters is to use active materials in the positive electrode that undergo redox reactions relative to a lithium (or carbon) negative electrode at voltages significantly above 4 V. However, state-of-the-art lithium-ion systems are rarely charged above about 4.2 V, because of undesirable side reactions. At these voltages, currently-available electrolytes may decompose, even though the electrode materials remain stable. Therefore, grant applications are sought to develop electrolytes (i.e., solvent mixtures plus conductive salts), for use in lithium-ion cells, that would operate at voltages of more that 4.8 V relative to lithium metal. In Phase I, the stability of the new electrolytes must be confirmed instrumentally. In Phase II, the electrolytes should be evaluated in lithium-ion cells of at least 1 Ah in size, using a positive electrode material that functions at more than 4.4 V relative to lithium metal.

Questions - contact James Barnes (james.barnes@ee.doe.gov)

d. Development of "High Voltage" Positive Electrode Materials for Use in Advanced Lithium-Ion Cells—Batteries in PHEVs have increased energy density and specific energy relative to the batteries now being used in HEVs. For a lithium-ion cell, one approach to increasing these parameters is to use active materials in the positive electrode that undergo redox reactions relative to a lithium (or carbon) negative electrode at voltages significantly above 4 V. However, state-of-the-art lithium-ion systems are rarely charged above about 4.2 V because of undesirable side reactions. Many currently-available positive electrode materials are unstable at these higher voltages. Therefore, grant applications are sought to develop positive electrode materials that

would operate in a rechargeable cell at voltages of more that 4.8 V relative to lithium metal. In Phase I, the stability and performance of the new material shall be confirmed in laboratory cells. In Phase II, the materials should be evaluated in lithium-ion cells of at least 1 Ah in size, using an electrolyte that is stable enough to allow the assessment of the properties of the electrode material. This electrolyte does not have to meet the requirements for use in a vehicle, such as calendar or cycle life.

Questions - contact James Barnes (james.barnes@ee.doe.gov)

References:

1. Links to the following Manuals are available at: http://avt.inl.gov/energy_storage_lib.shtml. These documents provide a good general basis for understanding the performance requirements for electric and hybrid electric vehicle energy storage devices.
   · FreedomCAR 42V Battery Test Manual
   · FreedomCAR Battery Test Manual for Power Assist Hybrid Electric Vehicles
   · PNGV Battery Test Manual, Revision 3
   · Electric Vehicle Capacitor Test Procedures
   · USABC Electric Vehicle Battery Test Procedure Manual, Revision 2

2. The internet site for the Batteries for Advanced Transportation Technologies (BATT) program at http://berc.lbl.gov/BATT/BATT.html includes quarterly and annual reports. This program addresses many long-term issues related to lithium batteries, including new materials and basic issues related to abuse tolerance.

3. This site contains multiple references that summarize work supported by the FreedomCAR and Vehicle Technologies Program related to energy storage. Prior to 2002, there are separate publications for the Energy Storage Effort and for Advanced Technology Development. In more recent years, there is a combined report for Energy Storage. These reports include information about cell chemistries that have proven to be useful model systems for these applications along with discussions of issues related to abuse tolerance and cell life. http://www.eere.energy.gov/vehiclesandfuels/resources/ .

4. Information about requirements for vehicular batteries, separators for lithium-ion batteries, and abuse testing can all be found at the USABC section of the USCAR internet site. Go to http://www.uscar.org/; click on "Teams"; under the USCAR Consortia section, click on "United States Advanced Battery Consortium (USABC)". This site provides a second source for many of the documents found at reference 1.

5. Information on the FreedomCAR goals and test procedures for lithium-ion battery separators are available by email from Jim Barnes, e-mail: James.Barnes@ee.doe.gov. If your email system will not accommodate files attached to a message, these documents can also be provided by fax.

12. NANOTECHNOLOGY

The United States has made considerable investment in nanotechnology research, with applications envisioned for medicine and health, National defense, electronics, and other areas. This topic solicits grant applications for nanotechnology research for energy efficiency and renewable energy applications, particularly to enhance efficiency in the ways that energy is converted and used in the U.S. Grant applications for "cross-cutting" uses of nanotechnology are especially encouraged – for example, the application of sensors and controls, originally developed for the Department of Defense, to a manufacturing industry for civilian applications. Grant applications must clearly demonstrate how the particular nanotechnology approach will save energy in the

buildings, industry, or transportation sectors, or in the conversion and storage of energy, including solar and wind energy conversion. Specific areas of interest include commodity manufacturing, building HVAC, lighting, refrigeration, power electronics, wind turbines, solar photovoltaics, solar thermal systems, high-temperature gas turbines, and technologies that could contribute to a hydrogen based economy. The wider the application and the greater the potential energy benefits, the better.

Grant applications are sought only in the following subtopics.

a. Nanomaterials for Industrial and Building Applications—Grant applications are sought to develop nanomaterials – i.e., materials that derive unique properties from a structure or function imparted to a material within the physical dimensions of 1-10 nanometers – for the enhancement of energy efficiency in the US manufacturing and building sectors. Approaches of interest may include materials that provide unique wear characteristics, high temperature characteristics, improved manufacturing capabilities, and improved building energy use in HVAC and lighting. "Cross-cutting" applications of new nanomaterials to the energy end-use sectors are especially encouraged.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

b. Nanotechnology Applications in Electronics, Sensors, and Controls—Grant applications are sought to apply nanotechnology to the development of electronics, sensors, and controls for increasing energy efficiency. Areas of interest include: (1) energy usage in manufacturing, buildings, or vehicles; (2) renewable energy conversion and storage; and (3) reduced electricity usage by computer components and peripherals.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

c. Nanotechnology Applications in Renewable Energy Conversion—Grant applications are sought to apply nanotechnology to improve the performance or increase the efficiency of renewable energy systems. Areas of particular interest include solar energy conversion (especially photovoltaics), wind energy, biomass power for utility applications, hydrogen production and storage for transportation, including the development of fuel cell technology, and geothermal energy. Because many of these areas already have been the subject of nanotechnology R&D, grant applications must include a review of the pertinent technical and patent literature.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

d. Nanomaterials for Lithium-Ion Batteries Used in Energy Storage—Lithium-ion cells represent the basic building blocks of batteries proposed for the next generation of advanced hybrid electric vehicles (HEVs). Most lithium-ion cells in production today use some form of carbon, composed of relatively spherical particles several microns in diameter, as the active material in the negative electrode. A new family of electrode materials is now being reported in the technical literature. Some of these materials, such as some alloys, perform poorly as electrode materials when they are prepared as relatively large particles, but perform much better when synthesized as nanoparticles. Therefore, grant applications are sought to develop new nanomaterials for use in the negative electrodes of lithium-ion cells that could be used in HEVs. To be attractive for HEV applications, the materials must be inexpensive, environmentally benign, and able to be charged and discharged at high rates for many cycles over a period of many years. (Specific performance goals for vehicular batteries are described in more detail in Topic 11.) Grant applications must: (1) provide a clear explanation as to why the selected materials would be expected to function in a cell and why the nanoparticle composition will offer performance benefits over current electrode materials; and (2) describe a viable pathway for the synthesis of these materials, along with a discussion any issues that may be associated with their use in

batteries. Phase I should include the synthesis of the nanomaterials in a reproducible manner, an assessment of chemical and physical properties, and a demonstration of performance in small lithium-ion cells. In Phase II, the synthetic methods should be refined so that the materials can be produced in larger quantities at a cost that is no more than that of carbons currently in use; the materials should be characterized to confirm that they can be fabricated into practical electrodes (i.e., coated onto an appropriate substrate); and the materials should be demonstrated in cells at least 200 mAh in size.

Questions – contact Charles Russomanno (Charles.Russomanno@ee.doe.gov)

References:

1 Chemicals Industry of the Future, U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www.eere.energy.gov/industry/chemicals/)

2 Building Technology Roadmaps, U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www.eere.energy.gov/buildings/tech/roadmaps.html)

3 Hydrogen, Fuel Cells and Infrastructure Technologies Program "Multi-Year Research, Development and Demonstration Plan", U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/)

4 Solar Energy Technologies Program, U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www1.eere.energy.gov/solar/)

5 FreedomCAR and Vehicle Technologies, "Multi-Year Program Plan", U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www1.eere.energy.gov/vehiclesandfuels/resources/fcvt_mypp.html

6 Building Technologies, "Multi-Year Program Plan," U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www.eere.energy.gov/buildings/about/mypp.html)

7 Industrial Technologies Program, "Strategic Plan," U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www1.eere.energy.gov/industry/about/strategic_plan.html)

13. ALTERNATIVE FEEDSTOCKS

The U.S. chemical industry used 6.4 quads of energy in 2004, 6.4% of the total U.S. energy consumption. Approximately 47% of this energy was used for fuel and power production, and 53% (3.4 quads) were used as feedstocks for the production of thousands of industrial products, including plastics, pharmaceuticals, electronic materials, and fertilizers. The chemical industry is the single largest user of natural gas, accounting for 10% of all U.S. natural gas consumption. Although coal, biomass, etc. could be used as hydrocarbon feedstocks, naptha, natural gas condensates, and natural gas itself account for 99% of the feedstock materials used by the chemical industry. Natural gas is predominately used to manufacture methanol and ammonia, and 70% of the U.S. olefins (particularly ethylene) production is based on natural gas condensates. As the U.S. supply of natural gas and natural gas condensate has decreased, and as prices have risen in the 2000s, the production of these chemicals has been transferred overseas. In 2004, about 50% of the U.S. methanol capacity was shutdown (45% for ammonia and 15% for ethylene), and the percentage transferred overseas has increased since that date. As a result, the U.S. chemical industry has a trade deficit for the first time in history, negatively impacting the U.S. GDP.

Efforts to increase industrial cost-competitiveness, boost energy efficiency, increase productivity, increase energy security, and prevent pollution will require that traditional chemical feedstocks (petroleum and natural gas) be supplemented with materials that are abundant in the U.S. In response to this need, the Department of Energy is seeking the development of alternative feedstock pathways for large-scale commodity chemical production (i.e., produced in quantities greater than 1 million tons/year). Near-term opportunities should focus on feedstock substitutions to make existing products with minimal changes in existing manufacturing facilities. Long-term opportunities will involve the manufacture of new products using new chemistries and potentially new processing equipment. Of particular interest are grant applications that offer the potential to improve the state of the art, be more cost effective than current techniques for producing alternative feedstocks, and be applicable to broad segments of the industry. Analyses have shown that promising applications for broad benefit include the production of olefins (ethylene, propylene, and butadiene), aromatics (benzene, toluene, and xylene), paraffinic derivatives (mono ethylene glycol, mono propylene glycol, and propylene oxide), acetone, and formaldehyde from biomass.

Grant applications must address the potential public benefits that the proposed technology would provide from the reduced consumption of petroleum and natural gas, and from reduced pollutants. Grant applications should include a review of the state-of-the-art of the targeted application in the U.S., including a review of current inefficiencies. Strategies to overcome these inefficiencies should be identified. Approaches must demonstrate an attractive cost over a practical range of energy costs; the cost of applying the new technology and the ease of implementation also should be considered.

Grant applications are sought only in the following subtopics.

a. Pretreatment/Biochemical—Pretreatment conditions and processes influence the reaction and/or re-arrangement of various biomass feedstock components, including agricultural residues, woody forest-land base residues, and herbaceous and/or woody energy crops. The identification of more cost-effective pretreatments could increase the economics and technical capabilities of bioconversion systems. These pretreatments must be properly matched to specific feedstock types, which span wide range of compositional and structural features, and to required enzyme activities and loadings. Parametric experimental studies can help to understand these relationships, in order to ensure that a variety of biomass feedstocks can be processed to achieve a target price of $1.07 per gallon.

Grant applications are sought to improve the physical and chemical pretreatment of biomass prior to fermentation. Approaches of interest include the development of new enzymes and/or new methods for enzyme pretreatment. Specific examples of possible approaches include:

- Employing cost-effective hemicellulases and other accessory enzymes in conjunction with cellulases could reduce the severity and cost of pretreatment. In particular, sugar degradation could be reduced significantly by understanding the kinetic mechanisms that lead to undesirable degradation products and then systematically blocking these mechanisms. Parametric studies could determine the relationship between sugar degradation and pretreatment conditions, with findings used to identify pretreatment conditions to reduce xylose degradation reactions to target levels. Lower sugar degradation losses have the potential to achieve a combined 90% xylose yield from pretreatment and enzymatic hydrolysis steps.

- Currently, a hydrolyzate conditioning step adds cost and complexity to the process and results in the potential loss of sugars available for fermentation to ethanol. The need for conditioning is intrinsically related to pretreatment processes and conditions, which influence: (1) the formation of potentially-inhibitory sugar degradation products; and (2) possible release of toxic compounds from lignin, portions of which could be solubilized under certain pretreatment conditions. A systematic approach, which

includes the release or formation of fewer inhibitory compounds during pretreatment coupled with the development of more robust ethanologen strains, could eliminate the hydrolyzate conditioning step.

Questions - contact Charles Russomanno (charles.russomanno@hq.doe.gov)

b. Fermentation of Cellulose-Based Biomass to Chemicals—Research has been funded for the conversion of biomass to liquid fuels via thermochemical gasification and fermentation. In addition, some research has been funded by the Department of Energy for the production of small-volume chemicals via fermentation technology using sugar-based biomass feedstock. However, much less research has been directed towards use of biomass as a feedstock for large-scale chemical production. Therefore, grant applications are sought to address technical issues that are unique to the use of alternative feedstocks for the production of commodity chemicals. Approaches of interest include: (1) improved separations for the pretreatment of cellulose, lignin, etc., and the removal of byproducts to allow use as feedstocks; (2) cost effective scale-up methodologies for biologically-based processes, to allow for the economic production of commodity chemicals; (3) fermentation technologies that produce feedstocks from cellulose-based biomass rather than from starch and sugar-based materials (such as corn and sugar cane), which compete with food chain components; and (4) the development of new chemical pathways is needed (e.g., alcohols to acids, aldehydes to acids, alcohols to aldehydes, acids to alcohols, and dehydration to lactones and anhydrides) when starting from materials that are more oxidized petrochemicals.

Questions - contact Charles Russomanno (charles.russomanno@hq.doe.gov)

c. Thermochemical Conversion of Biomass to Chemical Products—Chemical products from biomass can be grouped according to the size of their market and the value of the chemical product:

- Medium-volume, medium-value commodity chemicals typically have markets of at least 50 million pounds per year, with prices in the range of approximately $0.50 to $1.50/pound. The production of these materials from biomass provides opportunities for economic competitiveness and for reducing the need for imported petroleum. Although markets for these chemical bioproducts typically are substantially smaller than markets for biofuels, the chemical bioproducts can provide significantly higher profit margins.

- By comparison, large-volume, low-value commodity chemicals such as ethylene have relatively low profit margins, and it is difficult to produce these at competitive costs from biomass.

- Finally, low-volume, high-value specialty chemicals offer economic potential, but do not result in significant petroleum displacement.

Thermochemical conversion – an approach that uses thermal processing, chemistry, and catalysis – can be used to efficiently transform biomass into chemical products. The resultant products may be identical to products currently made from petroleum, or they can be composed of different chemicals that displace similar chemicals from petroleum. Grant applications are sought to determine the technical and economic feasibility of innovative approaches for producing chemical products using thermochemical conversion. Approaches of interest should target medium-volume commodity products with prices of approximately $0.50 to $1.50/pound and market potential of at least 50 million pounds per year. Approaches that target low-value commodity chemicals or low-volume specialty products are not of interest and will be declined. Grant applications may address either products identical to those currently made from petroleum or new chemical products from biomass, which could displace related chemicals products based on petroleum. If new chemicals are proposed, the applicant should clearly explain the rationale for estimating the market potential of at least 50 million pounds annually.

Questions - contact Charles Russomanno (charles.russomanno@hq.doe.gov)

d. Breeding Oilseeds for Higher Fractions of Vegetable Oil—Biodiesel production in the United States has been increasing rapidly, and expansion is expected to continue. At present, soybeans are the main source of biodiesel in the United States; yet, only a small fraction of the large diesel market can be supplied from soybean oil. While common soybeans are typically about 18% vegetable oil, other soybean varieties of soybeans have been shown to have a vegetable oil fraction approaching 30%, and other oilseeds (such as peanuts, canola/rapeseed, and sunflower) are in the 35 to 50% range (with some germplasm having even higher oil contents). As the biodiesel market expands, it will push up the price of vegetable oil relative to the oilseed meal, making a higher oil content more desirable. Therefore, grant applications are sought to enhance the potential quantity of domestically-produced biodiesel by: (1) increasing the oil content of soybean varieties, and (2) enhancing the potential oil content per acre of oilseeds by increasing yield and/or oil content of oilseeds grown on at least 100,000 acres. Approaches of interest should demonstrate an oil content of at least 25%.

Questions - contact Charles Russomanno (charles.russomanno@hq.doe.gov)

References:

1. Werpy, T. A., et al., (2005). *Top Value Added Chemicals from Biomass* (Volume 1). 27th Symposium on Biotechnology for Fuels and Chemicals: Program and Abstracts (NREL/BK-510-36826), 1-4 May 2005, Denver, Colorado. Golden, CO: National Renewable Energy Laboratory p. 20; NREL Report No. AB-510-39815. (Full Text available at: http://www.nrel.gov/publications/pdfs/epubs_2005_04-06.pdf)

2. Werpy, T.; Petersen, G., (2004). *Top Value Added Chemicals from Biomass: Volume I* -- Results of Screening for Potential Candidates from Sugars and Synthesis Gas. 76 pp.; NREL Report No. TP-510-35523; DOE/GO-102004-1992. (Full text available at: http://www1.eere.energy.gov/biomass/pdfs/35523.pdf)

3. Biobased Industrial Products: Research and Commercialization Priorities. Committee on Biobased Industrial Products, National Research Council, 2000. (URL: http://www.nap.edu/catalog/5295.html)

4. "Biomass as Feedstock for a Biorefinery and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply," USDOE/USDA, April 2005. (Full text available at: http://www.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf)

5. Energy Efficiency and Renewable Energy, Biomass program Website. (URL: http://www1.eere.energy.gov/biomass/)

OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH

14. ATMOSPHERIC MEASUREMENT TECHNOLOGY

World-wide energy production is modifying the chemical composition of the atmosphere, which is linked not only with environmental degradation and human health problems but also with changes in the most sensitive parts of the physical climate system – namely, clouds and aerosols. The Intergovernmental Panel on Climate Change's Fourth Assessment Report recently assessed how the Earth's energy balance has been and will be affected by changes in clouds and aerosols. It was determined that innovative measurement technologies are

needed to provide both input and comparison data for models used to assess the energetic impacts of clouds and aerosols. These technologies will require high accuracy and time stability, in order to support a strategy of sustainable and pollution-free energy development for the future.

Grant applications must propose Phase I bench tests of critical technologies with respect to the subtopics that follow. ("Critical technologies" refer to components, materials, equipment, or processes that overcome significant limitations to current capabilities.) Grant applications proposing only computer modeling without physical testing will be considered non-responsive. Grant applications also should describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities. Applications submitted to any of the subtopics should support claims of commercial potential for proposed technologies (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs).

Grant applications are sought only in the following subtopics:

a. Three-Dimensional (3-D) Measurements to Match Cloud Models—The cloud problem remains rather poorly understood in spite of decades of research. DOE's Atmospheric Radiation Measurement (ARM) Program has grappled with the cloud problem for over a decade and has made numerous advances in both observation and modeling, especially in the radiative forcing arena. However, an end-to-end understanding of cloud life cycle continues to be elusive, not least because the "cloud" and "precipitation" communities have remained staunchly separate. Seemingly simple things like the rapid formation of warm rain still excite vigorous debate and no community-consensus explanation or model has emerged. Convection, among other features, remains inadequately represented in climate models. While measurements alone cannot solve the cloud problem, they can help bring the cloud and precipitation communities onto common ground, and can help with the modeling effort. Stephens (2005) gives the scientific background for focusing on the cloud problem. Vali (1997) and Baumgardner et al. (2002) describe the kinds of instruments currently used for in situ cloud measurements. (Non-radar remote sensing instruments are of equal interest; there is a separate sub-topic for radar.) Examples of creative combination of in situ and remote sensing technologies are given in Polonsky et al. (2005) and Cahalan et al. (2005). McFarquhar (2007) describes ARM's Aerial Vehicle Program, for which in situ instruments would be intended.

Therefore, grant applications are sought to develop novel instruments to measure the following cloud variables (in rough order of decreasing priority): extinction; total water content (liquid plus ice); liquid and ice water content separately; radar reflectivity; effective radius; cloud condensation nuclei (CCN) concentration; in-cloud aerosol properties; cloud particle chemistry; absorption coefficient or single-scatter albedo; scattering phase function; drizzle and/or precipitation fraction of the total water content; size distribution from sub-micron to precipitation-sized; and supersaturation. Of particular interest are instruments that help scale-up from the tiny sample volumes of aircraft instruments to the large volumes of cloud models. (Even the most highly resolved cloud models have grid cells many meters on a side).
Proposed instruments can be remote sensing or *in situ*, surface or airborne (including small UAVs, kites, and balloons). Multi-wavelength rather than single-wavelength measurements are desirable, where relevant. Because many measurements are one-dimensional, there is an acute need to increase the dimensionality of measurements to match that of the models.

Questions – contact Rickey Petty at: (rick.petty@science.doe.gov)

b. Scanning Radar to Test Cloud Model Predictions—Because of the need to increase the dimensionality of observations to match that of cloud models, and because of the need to retrieve 3D fields of quantities that are actually predicted by cloud models, grant applications are sought to develop a scanning radar/radiometer system designed specifically to test cloud model predictions. The system should measure both cloud and precipitation particles over a 15-30 km horizontal range with a speed sufficient to capture cloud evolution, at least

approximately. Novel designs that provide matching angle resolution and rapid scan capability, for both the radar and radiometer modes, are of particular interest. Desirable characteristics of the cloud/precipitation radar/radiometer system include: (1) dual radar frequencies of 35 and 94 GHz with Doppler and polarimetric capability; (2) dual radiometer frequencies at 35 and 94 GHz with variable bandwidth, for the retrieval of liquid water path; (3) antenna beamwidths of 0.5 degree or better; (4) sensitivity of -40 dBZ at 5 km, with 60 m range resolution and 0.1 sec integration time, assuming a 0.3 dB per km one-way atmospheric loss for the 94-GHz radar system; (5) reliable design with minimal operator intervention and 24/7 operational capability; (6) flexibility to change operational characteristics remotely for both the radars and radiometers; (7) scan rate for the radar/radiometer mode of 6 degrees per sec or better; and (8) the ability to record Doppler spectra at both radar frequencies.

Questions – contact Rickey Petty at: (rick.petty@science.doe.gov)

c. Measurements of the Chemical Composition of Atmospheric Aerosols and Aerosol Precursors—There is a need to develop improved measurement methods to characterize the bulk and the size-resolved chemical composition of ambient aerosols in real time, particularly carbonaceous aerosols. Improved measurements would facilitate the identification of the origin of aerosols, i.e. primary versus secondary and fossil fuel versus biogenic. Also, these measurements could help elucidate how aerosol particles are processed in the atmosphere by chemical reactions and by clouds, and how their hygroscopic properties change as they age. This information is important because relatively little is known about organic and absorbing particles, which are abundant in many locations in the atmosphere. In particular, there is a need for instruments suitable for real-time measurements of the composition of particles at the molecular level. Although recent advances have led to the development of new instruments, such as particle mass spectrometers and single particle analyzers, these instruments have important limitations in their ability to quantify black carbon vs. organic carbon, provide speciation of refractory and volatile organic compounds, and calibrate both organic and inorganic components. Further, instruments that otherwise would be suitable for ground-based operation often have limitations (size, weight, power, stability, etc.) that restrict their application for *in situ* measurements, where critical atmospheric processes actually occur (e.g., in or near clouds).

- **Aerosol Chemistry** – In order to better understand the chemical composition of atmospheric aerosols, grant applications are sought to develop improved instruments, or entirely new measurement methods, that provide: (1) speciation of individual organics, including those containing oxygen, nitrogen, and sulfur; (2) identification of elemental carbon and other carbonaceous material, so that the makeup of the absorbing fraction is known; (3) identification of source markers, such as isotopic abundances in aerosols; and (4) the ability to probe the chemical composition of aerosol surfaces;

- **Aerosol Precursors** – In order to better understand the evolution of aerosols in clouds, grant applications are sought to develop instruments that can make fast measurements of gas phase organics or other substances that might either condense or dissolve into preexisting aerosols or cloud droplets. One possible approach includes improvements in gas phase chemistry; for example, gas phase measurements of H_2SO_4, a major aerosol precursor, have revealed a wealth of new information in the last decade.

In order to address deficiencies associated with current techniques, proposed approaches should seek to provide: (1) quantifiable results over a wide range of compounds – a problem for laser ablation aerosol mass spectrometer methods; (2) measurements over a range of volatility so that dust, carbon, and salt are detectable – a problem for thermal decomposition aerosol mass spectrometers; and (3) measurements with high time resolution – an inherent problem with filter techniques. Finally, improved measurements of aerosol chemical composition from airborne platforms would be of particular interest.

Questions – contact Ashley Williamson at: (Ashley.Williamson@science.doe.gov)

d. Measurements of Other Characteristics of Atmospheric Aerosols—Improved instrumentation is needed to measure other, non-chemical, characteristics of atmospheric aerosols and for techniques to understand other characteristics of atmospheric aerosols:

- **Aerosol absorption**. The aerosol absorption coefficient, together with the aerosol scattering coefficient, determines the single-scattering albedo. This key aerosol property, along with the factors that contribute to it, are critical for determining heating rates and climate forcing by aerosols. Therefore, grant applications are sought to develop reliable instruments for the *in situ* measurement of the single-scattering albedo for particles containing black and organic carbon, dust, and minerals. The measurements must cover the solar wavelengths (UV, visible, and near infrared), must not alter aerosol properties, and must address the influence of relative humidity.

- **Aerosol size distributions**. Knowledge of the particle size distribution is essential for describing both direct and indirect radiative forcing by aerosols. However, current techniques for determining these distributions are often ambiguous because of the assumption that the particles are spherical. In particular, the optical techniques most often used in the 0.5-10 μm size range have inherent problems. Therefore, grant applications are sought for techniques, which are not based on optical properties, to determine the size distribution of ambient aerosols in the 0.5-10 μm size range. The techniques must address the influence of relative humidity and must be integrated with the simultaneous measurements of such properties as mass, area (extinction), and number.

- **Aerosol Scattering Coefficient and Phase Function.** The radiative forcing of aerosols depends on the vertical distribution of the aerosol scattering coefficient, the absorption coefficient, and the phase function. For the usual situation of optically thin aerosols, the top-of-the-atmosphere radiative forcing depends only on the scattering coefficient and phase function (and solar zenith angle). The phase function of aerosols is highly variable, depending on the size distribution and (for dust and soot aerosols) on particle shape. *In situ* techniques can measure the scattering coefficient and potentially the phase function. However, these techniques depend on the reconstruction of inhomogeneous vertical profiles from samples taken by aircraft at a small number of atmospheric levels. Unfortunately, these reconstructions are error prone because the aircraft observations are severely limited in frequency of operation. Other remote sensing techniques (e.g., Raman lidar) can measure profiles of aerosol backscattering and extinction, but not the complete phase function needed to calculate the radiative forcing. Therefore, grant applications are sought to develop new ground-based instrument technology for the remote sensing of aerosol scattering coefficient and phase function. Measurement of partial information about aerosol phase functions, such as asymmetry parameter, backscatter fraction, or the detailed function over a substantial portion of scattering angle, will be considered responsive. The instrumentation should be able to measure the required aerosol optical properties for typical rural continental aerosol loadings. Although measurements throughout the lower troposphere are preferred, it will still be acceptable if the measurements can be made in the boundary layer, at least.

Questions – contact Ashley Williamson at: (Ashley.Williamson@science.doe.gov)

Subtopic a References:

1 Baumgardner, D., et al, "Clouds: Measurement Techniques In Situ" in Encyclopedia of Atmospheric Sciences. J. R. Holton, Curry J. A., and Pyle J. (eds.), Academic Press, London, pp 489-498. 2002. (ISBN-10: 0-12-227090-8) (ISBN-13: 978-0-12-2277090-1)

2 Cahalan, R. F., et al, “THOR — Cloud Thickness from Offbeam Lidar Returns”. *Journal of Atmospheric*

and Oceanic Technology, 22, 605-627. 2005.

3 McFarquhar, G., "The Development of a Routine Observational Program with Piloted and Unpiloted Aerospace Vehicles: New Directions for ARM UAV", a white paper. 2007. (Full report available at: http://www.atmos.uiuc.edu/~mcfarq/aavp.whitepaperoverview.pdf)

4 Polonsky, I.N., Love, S. P., and Davis, A. B., "Wide-Angle Imaging Lidar Deployment at the ARM Southern Great Plains site: Intercomparison of cloud property retrievals", *Journal of Atmospheric and Oceanic Technology*, 22, 628-648. 2005.

5 Stephens, G., Cloud feedbacks in the climate system: A critical review," *J. Climate,* 18, 237-273. 2005. (ISSN: 1520-0442)

6 Vali, G., 1997: "Cloud properties measured from aircraft - An assessment." Paper presented at the WMO Workshop on Measurements of Cloud Properties for Forecasts of Weather, Air Quality and Climate. June 23-27, 1997, Mexico City, Mexico. Published as WMP REPORT No. 30 - WMO/TD 852 pp. 37-55. (Full report available at: http://www.atmos.uwyo.edu/~vali/mex_mms.pdf)

Subtopic b References:

1 Because of the need to increase the dimensionality of observations to match that of cloud models, and because of the need to retrieve 3D fields of quantities that are actually predicted by cloud models, grant applications are sought to develop a scanning radar/radiometer system designed specifically to test cloud model predictions (e.g. Frisch et al., 1998; Hogan et al., 2002; Kollias et al., 2007a,b; Vivekanadan et al., 1999).

2 Frisch, A. S., G. Feingold, C. W. Fairall, T. Uttal and J. B. Snider, 1998: On cloud radar and microwave radiometer measurements of stratus cloud liquid water profiles. *Journal of Geophysical Research,* 103, 23195-23197.

3 Hogan, R. J., N. Gaussiat and A. J. Illingworth, 2005: Stratocumulus liquid water content from dual-wavelength radar, *Journal of Atmospheric and Oceanic Technology,* 22, 1207-1218.

4 Kollias, P., E. Clothiaux, M.A. Miller, E.P. Luke, K.L. Johnson, K.P. Moran, K.B. Widener, and B.A. Albrecht, 2007a: The Atmospheric Radiation Measurement Program cloud profiling radars: Second-Generation sampling strategies, processing, and cloud data products. *Journal of Atmospheric and Oceanic Technology*, 24, 1199–1214.

5 Kollias, P., E. E. Clothiaux, M. A. Miller, B. A. Albrecht, G. L. Stephens and T. P. Ackerman, 2007b: Millimeter-wavelength radars – New frontier in atmospheric cloud and precipitation research. *Bulletin of the American Meteorological Society*. (in press, October, 2007).

6 Vivekanandan, J., B.E. Martner, M.K Politovich, and Guifu Zhang, 1999**:** Retrieval of atmospheric liquid and ice characteristics using dual-wavelength radar observations. *IEEE Trans. Geoscience Remote Sensing*, 37, 2325 – 2334.

Subtopic c references:

1 "Global Change Subcommittee of the Biological and Environmental Research Advisory Committee (BERAC)", *A Reconfigured Atmospheric Science Program, Technical Report,* pp. 18-21, U.S. DOE Office

of Biological and Environmental Research, April 2004. (Full text available at: http://www.er.doe.gov/production/ober/berac/ASP.pdf)

Subtopic d References:

1 Frisch, A. S., et al, "On Cloud Radar and Microwave Radiometer Measurements of Stratus Cloud Liquid Water Profiles". *Journal of Geophysical Research*, 103, 23195-23197. 1998. (Full text is available at: http://www.agu.org/pubs/crossref/1998/98JD01827.shtml)

2 Hogan, R. J., N. Gaussiat and A. J. Illingworth, "Stratocumulus Liquid Water Content from Dual-Wavelength Radar", *Journal of Atmospheric and Oceanic Technology*, 22(8), 1207-1218. 2005 (Full text available at: http://ams.allenpress.com/perlserv/?request=get-toc&issn=1520-0426&volume=22&issue=8)

3 Kollias, P., et al, "The Atmospheric Radiation Measurement Program Cloud Profiling Radars: Second-Generation Sampling Strategies, Processing, and Cloud Data Products". *Journal of Atmospheric and Oceanic Technology*, 24(7), 1199–1214. 2007. (Full text available at: http://ams.allenpress.com/perlserv/?request=get-toc&issn=1520-0426&volume=24&issue=7)

4 Kollias, P., et al, "Millimeter-Wavelength Radars – New Frontier in Atmospheric Cloud and Precipitation Research". *Bulletin of the American Meteorological Society*, 88, 2007. (Full text available at: http://ams.allenpress.com/perlserv/?request=get-archive&issn=1520-0477&volume=88)

5 Vivekanandan, J., et al, "Retrieval of Atmospheric Liquid and Ice Characteristics using Dual-Wavelength Radar Observations", IEEE Trans. *Geoscience Remote Sensing*, 37, 2325 – 2334. 1999. (Full article available at: http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/36/17110/00789629.pdf?arnumber=789629)

15. GENOMES-TO-LIFE (GTL) AND RELATED BIOTECHNOLOGIES

The Department of Energy (DOE) supports research to acquire a fundamental understanding of biological and environmental processes. This includes the display of genomes as DNA sequences; the functional characterization of gene products, especially from DOE-relevant plants and microbes; structural biology user stations at synchrotron sources and neutron sources; computational genomics; and the development of integrated information systems. This topic is focused on the goals of the Genomes to Life (GTL) program: namely, to develop a detailed understanding of the molecular machines of DOE-relevant microbes and their networking in living cells and microbial communities. Microbes with capabilities that can further several DOE programmatic missions are being used as the current subjects for these studies. The genome knowledge thus gained is enabling both the public and private sectors to: apply genome knowledge to the bio-production of energy, promote environmental applications such as bioremediation and carbon sequestration, promote cleaner industrial processes, and enable increasingly effective computational models of the microbial cell. For some of the subtopics below, capabilities already exist in a few laboratories, but commercial involvement will be needed before the technology can be exported to the broader research community.

Grant applications are sought only in the following subtopics:

a. Innovative Protein Production Technology in Microbes and Plants—A number of proteomics tasks are being pursued to achieve the goals of the GTL program. These tasks include high-throughput production and purification of proteins, correlation of proteins with the genes encoding their primary structure, identification of

protein isoforms encoded by the same gene, identification of memberships in functional complexes of proteins, and identification of the variations of proteome constituents under change to useful physiological states. However, a number of obstacles hinder the efficient accomplishment of these tasks. For example, several host-vector systems are available for the production of proteins encoded in a hyper-expressed source gene; yet, for some source genes, the proteins fail to fold into physiologically effective three-dimensional conformations (entrapment in insoluble inclusion bodies is one cause of such failures). Another difficulty is that proteins targeted to membranes are difficult to produce and isolate. Lastly, the lack of affinity reagents, which bind to proteins in their native conformations, adversely impacts structure, protein association, and function analyses. Therefore, grant applications are sought for the improved recovery and analysis of effective proteins. Areas of interest include: (1) the production of solubilized membrane proteins in active conformations, with or without post-translational modifications; (2) the development of synthetic membranes or nano-structures enabling analyses of membrane proteins; (3) and the development of improved affinity reagents.

Questions - contact Marvin Stodolsky (marvin.stodolsky@science.doe.gov)

b. Improved Technology for Transformation of Microbial and Plant Cells—Genetic engineering is now easy for most long studied microbes, with robust technologies available for gene transformation and mutagenesis. But for many microbes and plants of recent interest for processing plant mass into biofuels, capabilities for genetic engineering are still rudimentary. However, these capabilities are needed to enhance our fundamental understanding of gene function and regulation, especially for enhancing biofuel production capabilities. Grant applications are sought for improved genetic engineering of plants and microbes of biofuel interest by: (1) increasing the efficiency and fidelity of homologous recombination in plants (especially perennial grasses), and (2) more efficient DNA transformation of the cogent microbes.

Questions - contact Marvin Stodolsky (marvin.stodolsky@science.doe.gov)

c. Microbe-Based Fuel Production—Biotechnology offers the promise of capitalizing on the natural capabilities found in the microbial world to produce new fuels, leading to a reduction in green house gas emissions. Therefore, grant applications are sought to take advantage of advances in GTL science, as well as in systems biology, to simplify and consolidate the conversion of cellulose to ethanol or other high value fuels. Emphasis should be placed on developing process improvements from externally-generated biologically-derived catalysts, single organisms, and/or integrated microbial systems composed of a stable consortium of organisms. Approaches of interest include improving the pretreatment of lignocellulosic material for saccharification and developing organisms that: (1) thrive in optimal bioreactor temperatures and pH environments; (2) ferment both C5 and C6 sugars; and (3) catalyze products in spite of inhibitors, including high concentrations of ethanol. Proposed approaches should coordinate with the research goals described in the DOE GTL Roadmap [7] and Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda [8].

Questions - contact Marvin Stodolsky (marvin.stodolsky@science.doe.gov)

d. Instrumentation for Biofilms and Anaerobic Bacteria—Much microbial action proceeds through the formation of biofilms on substrate surfaces or air-water interfaces, at which there may be substantive functional heterogeneity with depth. Therefore, grant applications are sought to develop instrumentation for better analyzing biofilms, especially analytical capabilities to reveal the differing functional roles with depth and to identify the non-cellular biofilm constituents.

Many microbes of interest for biofuel and environmental remediation applications are strict anaerobes, with interesting enzymatic activities that can only be assayed under anaerobic conditions. Therefore, grant

applications are sought to develop enclosures with complementary instrumentation for performing cloning and processing of strict anaerobes, including biochemical assays that can perform without the destruction of oxygen sensitive enzymes.

Questions - contact Marvin Stodolsky (marvin.stodolsky@science.doe.gov)

References:

1 U.S. DOE GTL Bioenergy Research Center Competition. (URL: News release: http://www.doe.gov/news/3872.htm Details: http://www.grants.gov/search/search.do?oppId=10474&mode=VIEW)

2 "Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda," U.S. DOE Office of Science and Office of Energy Efficiency and Renewable Energy, June 2006. (Report No. DOE/SC/EE-0095) (Available at: http://genomicsgtl.energy.gov/biofuels/b2bworkshop.shtml)

3 "Genomics:GTL Roadmap," Systems Biology for Energy and Environment Website, U.S. DOE Office of Science, August 2005. (URL: http://doegenomestolife.org/roadmap/index.shtml)

4 Year 2006 DOE SBIR Awards in the Genomes-To-Life (GTL) Program. (URL: http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle24/phase1/p1_award.htm Scroll down to awards in 8th topic: GENOMES-TO-LIFE AND RELATED BIOTECHNOLOGIES within http://www.science.doe.gov/sbir/awards_abstracts/sbirsttr/cycle23/phase2/p2_award.htm Scroll down to awards in 5th topic: GENOMICS: GENOMES-TO-LIFE AND RELATED BIOTECHNOLOGIES)

5 DOE Joint Genome Institute Website, U.S. DOE Office of Biological and Environmental Research (OBER). (URL: http://www.jgi.doe.gov)

6 Genomics:GTL—Systems Biology for Energy and Environment Website, U.S. DOE OBER/Office of Advanced Scientific Computing Research. (URL: http://doegenomestolife.org/)

7 Research Abstracts from the Genomics: GTL Contractor—Grantee Workshop IV, North Bethesda, MD, February 2006. (URL: http://doegenomestolife.org/pubs/2006abstracts/index.shtml)

8 Research Topics Website, U.S. DOE OBER. (URL: http://www.sc.doe.gov/production/ober/restopic.html)

9 Hydrogen Production and Delivery: Photolytic Processes Website, U.S. DOE Office of Energy Efficiency and Renewable Energy. (URL: http://www.eere.energy.gov/hydrogenandfuelcells/production/photo_processes.html)

16. CARBON CYCLE MEASUREMENTS OF THE ATMOSPHERE AND THE BIOSPHERE

Eighty-five percent of our nation's energy results from the burning of fossil fuels from vast reservoirs of coal, oil, and natural gas. These processes add carbon to the atmosphere, principally in the form of carbon dioxide (CO_2). It is important to understand the fate of this excess CO_2 in the global carbon cycle in order to assess the terrestrial ecosystem response, the sensitivity of climate, and the potential for sequestration in natural carbon sinks of lands and oceans. Therefore, improved measurement approaches are needed to quantify carbon changes in components of the global carbon cycle, particularly the terrestrial biosphere, in order to improve understanding and assess the potential for future carbon sequestration.

A DOE working paper on carbon sequestration science and technology describes research needs and technology requirements for sequestering carbon by ocean and terrestrial systems (see Reference 1). This document calls for substantially improved technology for measuring carbon transformation of the atmosphere and biosphere. The document also describes advanced sensor technology and measurement approaches that are needed for detecting changes of carbon quantities of terrestrial (including biotic, microbial, and soil components) and oceanic systems, and for evaluating relationships between these carbon cycle components and the atmosphere.

Grant applications submitted to this topic should demonstrate performance characteristics of proposed measurement systems, and show a capability for deployment at field scales ranging from experimental plot size (meters to hectares of land – with comparable dimensions for marine systems) to nominal dimensions of ecosystems (hectares to square kilometers). Phase I projects must perform feasibility and/or field tests of proposed measurement systems to assure a high degree of reliability and robustness. Combinations of stationary remote and *in situ* approaches will be considered, and priority will be given to ideas/approaches for verifying biosphere carbon changes and for estimating carbon sequestration. Measurements using aircraft or ballon platforms must be explicitly linked to real-time ground-based measurements. Grant applications based on satellite remote sensing platforms are beyond the scope of this topic, and will be declined.

Grant applications are sought only in the following subtopics:

a. Sensors and Techniques for Measuring Terrestrial Carbon Sinks and Sources—Measurement technology is required to quantify carbon sequestration by natural vegetation and ecosystems (i.e., carbon sinks) as well as CO_2 emissions to the atmosphere from natural or industrial sources. Grant applications are sought to develop sensors and unique measurement techniques (and associated system technology, if appropriate) to detect and quantify annual net carbon changes of terrestrial vegetation for large areas, or to measure and verify the magnitude of CO_2 emissions from various sources. Approaches of interest include the development of sensors to measure fluxes between the atmosphere and land-surface vegetation, new technology for accurate measurement of soil carbon content and change, and the development of miniaturized sensors to determine atmospheric CO_2 concentration. For the measurement of CO_2 sinks, the sensor systems or new technology must be applicable for forests, grasslands, shrub lands, agricultural lands, and/or wetlands, and have the capability of producing spatially resolved aggregate estimates of terrestrial carbon changes to an accuracy of 10 to 25 $g/m^2/yr$ (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty. For measuring emissions or atmospheric concentrations, the apparatus must be located at a point remote from the actual site of CO_2 release and provide accuracy estimates for CO_2 concentrations of approximately 0.3 ppm or less in dry air. Mechanical sensors must be durable in the full range of normal environmental conditions and exposures, including exposure to dust, rain, snow, heat, extreme cold, and fog. Operation in unattended, remote locations for weeks at a time, without degradation of the measurement, is also required; however, daily telecommunication with the system for monitoring performance and detecting potential operational problems would be desirable.

Proposed approaches, including both mechanical sensors and non-mechanical technology should consist of new, innovative methodologies that are significant advances over conventional scientific approaches used to measure CO_2, carbon, and related compounds. Specifically, the measurement systems should be different from, or substantially augment, existing techniques for eddy flux (covariance) methods and routine monitoring of atmospheric CO_2 concentrations, or for estimating carbon quantities of land and/or ocean constituents of the carbon cycle. Grant applications proposing *in situ* or in-stream measurement of flue gas emissions will be declined, as will applications that offer only incremental or marginal improvements over existing measurement systems.

Questions - contact Roger Dahlman (roger.dahlman@science.doe.gov)

b. Novel Measurements of Carbon, CO_2, and Trace Greenhouse Gas Constituents of Terrestrial and Atmospheric Media—Improved measurement technology is needed to better characterize processes involving carbon transformations of soil, vegetation, and associated ecosystem components and exchanges with the atmosphere. Particular areas of interest include high resolution measurements of soil carbon/organic matter – i.e., the carbon content of biological tissues in various components (e.g., phytomass, detritus) of terrestrial ecosystems – as described in item (1) below; improved measurement technology for atmospheric CO_2, as described in items (2) and (3) below; and high accuracy and precision measurement of other trace greenhouse gases as described in item (4) below.

(1) For determining the carbon content of biota and soil, grant applications are sought to develop and demonstrate measurement technology for estimating changes of carbon quantities and/or fluxes involving major components of ecosystems, with an accuracy on the order of 10 grams per square meter or less. Quantification of spatially resolved aggregate estimates of terrestrial carbon changes should have an accuracy of 10 to 25 $g/m^2/yr$ (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty.

(2) Grant applications are sought to design and demonstrate a new CO_2 analyzer that: (a) can determine the mole fraction of CO_2 in dry ambient air to a relative precision of 1 part in 3000 or better in one minute or less; (b) operates with small amounts of gas (30 cc/min or less) to minimize problems due to water vapor and to minimize consumption of reference gases, if employed; (c) is robust enough for unattended field deployment for periods of half a year or longer; (d) costs less than $5000 when manufactured in quantity; and (e) is not sensitive to motion.

(3) Grant applications are sought to develop instruments for measuring atmospheric CO_2, lightweight (approximately 100 grams) sensors, which are capable of measuring fluctuations of CO_2 in air of the order of plus or minus 1 ppm in a background of 370 ppm. The devices must be suitable for launch on ballonsondes or similar such platforms, and therefore must be insensitive to large changes in ambient temperature and pressure. The devices also must be able to operate on low power (e.g., 9v battery), and have a response time of less than 30 seconds.

(4) Grant applications are also sought to develop new technology platforms that can be used to measure fluxes and/or concentrations of important trace greenhouse gas constituents and the isotopes of carbon, methane, CO, and other trace species. New instrumentation designs must have high potential for direct application for determining carbon, CO, and trace species sources and sinks. Also, design elements that ensure long-term and robust field deployment, should be included.

In general, new technology for measuring terrestrial biota and soil must be accomplished by *in situ* and/or non-invasive means and/or remote sensing of organic carbon forms across a range of temporal scales (from seconds to days) and spatial scales (from millimeters to kilometers), depending on the system properties being observed. Instruments must be portable and deployable in remote locations, and must not adversely impact the site of deployment. The term "remote sensing" means that the observation method is physically separated from the object of interest. Research that develops unique surface-based observations and uses them for the calibration/interpretation of other remotely derived data is of interest; however, except for the potential application of CO_2 sensors via ballonsonde, other methods of remote sensing data acquisition by airborne or satellite platforms will not be considered.

Questions - contact Roger Dahlman (roger.dahlman@science.doe.gov)

References:

1 Abraham S., et al., US Climate Change Technology Program—Technology Optionsfor the Near and Long Term, November 2003. (Full text available at: http://www.climatetechnology.gov/library/2003/tech-options/index.htm)

2 Allen, L. H., Jr., et al., eds., "Advances in Carbon Dioxide Effects Research", American Society of Agronomy, Special Publication No. 61, Madison, WI: ASA, CSSA, and SSSA, 1997. (ISBN: 0-8911-81334)

3 Daniels, D. J., "Surface Penetrating Radar", London: The Institution of Electrical Engineers, 1996. (ISBN: 0-8529-68620)

4 Dilling L., et al., "The Role of Carbon Cycle Observations and Knowledge in Carbon Management," *Annual Review of Environment and Resources*, 28: 521-558, November 2003. (ISSN: 1543-5938) (Abstract and ordering information available at: http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.energy.28.011503.163443)

5 Ebinger, M. H., et al., "Extending the Applicability of Laser-Induced Breakdown Spectroscopy for Total Soil Carbon Measurement," *Soil Science Society of America Journal*, 67:1616-1619, 2003. (ISSN: 0361-5995) (Abstract and ordering information available at: http://soil.scijournals.org/cgi/content/abstract/67/5/1616)

6 Hall, D. O., et al., eds., *Photosynthesis and Production in a Changing Environment: A Field and Laboratory Manual*, New York: Chapman & Hall, 1993. (ISBN: 0-4124-29004)

7 Hashimoto, Y., et al., eds., Measurement Techniques in Plant Science, San Diego: Academic Press, Inc., 1990. (ISBN: 0-1233-05853)

8 McMichael, B. L. and Persson, H., eds., Plant Roots and Their Environment: Proceedings of an ISRR Symposium, Uppsala, Sweden, August 21-26*, 1988*, New York: Elsevier, 1991. (ISBN: 0-4448-91048)

9 National Academy of Engineering/National Research Council Board on Energy and Environmental Systems, *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*, especially pages 101-103 Washington, D.C.: National Academy Press, 2004. (Full text available at: http://books.nap.edu/books/0309091632/html/index.html)

10 Nelson, D. W. and Sommers, L. E., "Total Carbon, Organic Carbon, and Organic Matter," Methods of Soil Analysis, Part 3: Chemical Methods, pp. 961-1010, Madison, WI: Soil Science Society of America, 1996. (ISBN: 0-8911-88258)

11 Rozema, J., et al., eds., CO_2 and Biosphere, Hingham, MA: Kluwer Academic Publishers, 1993. (ISBN: 0-7923-20441) (This publication is part of a monographic series, *Advances in Vegetation Science*, Vol. 14 - ISSN: 0168-8022) (Reprinted from *Vegetation*, 104/105, January 1993 - ISSN: 0042-3106. Now called *Plant Ecology* - ISSN: 1385-0237)

12 Schimel, D., et al., "Carbon Sequestration Studied in Western U.S. Mountains," *EOS Transactions*, 83(40): 445-449, Washington, DC: American Geophysical Union, 2002. (ISSN: 0096-3941)

13 Swift, R., "Organic Matter Characterization," Methods of Soil Analysis, Part 3: Chemical Methods, pp. 1011-1070, Madison, WI: Soil Science Society of America, 1996. (ISBN: 0-8911-88258)

17. TECHNOLOGIES FOR SUBSURFACE CHARACTERIZATION AND MONITORING

New measurement and monitoring tools for interrogating physical, chemical and biological, processes in subsurface environments are important elements of Department of Energy (DOE) research efforts to support the assessment of remediation performance and DOE site stewardship. The purpose of these research efforts is to determine the fate and transport of contaminants generated from past weapons production activities, assess and control processes to remediate contaminants, and provide for the long-term monitoring of sites. A description of the nature and extent of contamination at the principal DOE sites is available at http://www.nap.edu/books/0309065496/html/index.html/.

Grant applications submitted to this topic must describe why and how the proposed *in situ* fieldable technologies will substantially improve the state-of-the-art, include bench and/or field tests to demonstrate the technology, and clearly state the projected dates for likely operational deployment. New or advanced technologies, which can be demonstrated to operate under field conditions with mixed/multiple contaminants and can be deployed in 2-3 years, will receive selection priority. Claims of relevance to DOE sites, or of commercial potential for proposed technologies, must be supported by endorsements from relevant site managers, market analyses, or the identification of commercial spin-offs. Grant applications that propose incremental improvements to existing technologies are not of interest and will be declined.

For some of the following subtopics, collaboration with government laboratories or universities, either during or after the SBIR/STTR project, may speed the development and field evaluation of the measurement or monitoring technology. In addition, some of these organizations operate user facilities that may be of value to proposed projects. These facilities include:

- Integrated Field Challenge (IFC) research sites in Oak Ridge, TN (http://www.esd.ornl.gov/nabirfrc/); Old Rifle, CO (http://www.pnl.gov/nabir-umtra/index.stm); and Hanford, WA (http://www.lbl.gov/ERSP/generalinfo/pi_meetings/April07/Posters/zachara_multi_ersp07poster.pdf). At the IFC research sites scientists can conduct field-scale research and obtain DOE-relevant samples of soils, sediments, and ground waters for laboratory research.

- The Environmental Molecular Science Laboratory (EMSL) at the Pacific Northwest National Laboratory (http://www.emsl.pnl.gov). EMSL is a national scientific user facility with state-of-the-art instrumentation in environmental spectroscopy, high field magnetic resonance, high performance mass spectroscopy, high resolution electron microscopy, x-ray diffraction, and high performance computing.

Grant applications must describe, in the technical approach or work plan, the purpose and specific benefits of any proposed teaming arrangements.

Grant applications are sought only in the following subtopics:

a. Mapping and Monitoring Hydrogeologic Processes in the Shallow Subsurface—Grant applications are sought to develop high-resolution geophysical methods to: (1) characterize hydrogeologic properties that control the transport and dispersion of contaminants in the subsurface, or (2) monitor dynamic processes such as fluid flow, contaminant transport, and geochemical and microbial activity in the subsurface. While geophysical characterization methods are improving and yielding higher-resolution data, they are still not routinely used to describe flow and transport processes or to guide remediation activities. Therefore, grant applications also are sought to develop integrated approaches where geophysical data are combined with other sources (e.g., core analyses, well logs, hydrogeologic and geochemical information) to better constrain and evaluate flow and transport models. The development of improved methods for the long-term monitoring (for one year, ten year, and one hundred year time frames) of contaminated sites, using integrated geophysical sensor networks, is also of interest.

Questions - contact David Lesmes (david.lesmes@science.doe.gov)

b. Real-Time, *In Situ* Measurements of Geochemical, Biogeochemical and Microbial Processes in the Subsurface—Sensitive, accurate, and real-time monitoring of geochemical, biogeochemical and microbial conditions are needed in subsurface environments, including: groundwater, sediments, and biofilms. In particular, highly selective, sensitive, and rugged *in situ* devices are needed for low-cost field deployment in remote locations, in order to enhance our ability to monitor processes at finer levels of resolution and over broader areas. Therefore, grant applications are sought to develop innovative sensors and systems to detect and monitor geochemical and biogeochemical processes that control the chemical speciation or transport of metals and radionuclides in the subsurface. Only the following radionuclides and metals are of interest: technetium, chromium, strontium, mercury, uranium, plutonium, americium, cesium, and cobalt. Grant applications that address other contaminants will be declined. In addition, the microbes and metabolic processes of interest are limited to those that may be involved in controlling the subsurface fate, transport, and remediation of these elements. Grant applications must provide convincing documentation (experimental data, calculations, etc.) to show that the sensing method is both highly sensitive (i.e., low detection limit), precise, and highly selective to the target analyte, microbe, or microbial association (i.e., free of anticipated physical/chemical/biological interferences). Approaches that leave significant doubt regarding sensor functionality in realistic multi-component samples and realistic field conditions will not be considered.

Grant applications also are sought to develop integrated sensing systems for autonomous or unattended applications of the above measurement needs. The integrated system should include all of the components necessary for a complete sensor package (such as micro-machined pumps, valves, and micro-sensors) for field applications in the subsurface. Approaches of interest include: (1) fiber optic, solid-state, chemical, or silicon micro-machined sensors; and (2) biosensors (devices employing biological molecules or systems in the sensing elements) that can be used in the field – the biosensor systems may incorporate, but are not limited to, whole cell biosensors (i.e., chemiluminescent or bioluminescent systems), enzyme or immunology-linked detection systems (e.g., enzyme-linked immunosensors incorporating colorimetric or fluorescent portable detectors), lipid characterization systems, or DNA/RNA probe technology with amplification and hybridization. Substantial progress has been made in fiber optics and chemical sensing technology in the last decade; therefore, grant applications that propose minor adaptations of readily available materials/hardware, and/or can not demonstrate substantial improvements over the current state of the art, are not of interest and will be declined.

Questions - contact David Lesmes (david.lesmes@science.doe.gov)

References

1. Environmental Remediation Sciences Division, Office of Biological & Environmental Research Website. (URL: http://www.science.doe.gov/ober/ERSD_top.html)

2. "A Strategic Vision for Department of Energy Environmental Quality of Research and Development", National Research Council, National Academy Press, 2001. (Full text available at: http://lab.nap.edu/nap-cgi/discover.cgi?term=strategic%20vision&restric=NAP)

3. "Science and Technology for Environmental Cleanup at Hanford", National Research Council, National Academy Press, 2001. (Full text available at: http://books.nap.edu/openbook/0309075963/html/index.html).

4. Research Needs in Subsurface Science, U.S. DOE Environmental Management Science Program, National Academy Press, 2000. (ISBN: 0-3090-66468) (Full text available at: http://books.nap.edu/openbook/0309066468/html/index.html)

5. "Seeing into the Earth: Noninvasive Characterization of the Shallow Subsurface for Environment and Engineering Application", National Research Council, U.S. DOE Environmental Management Science Program, National Academy Press, 2000. (Full text available at: http://books.nap.edu/openbook/0309063590/html/index.html)

6. *A Report to Congress on Long-Term Stewardship*, Washington, DC: U.S. DOE Office of Environmental Management, 2001. (Full text available at: http://lts.apps.em.doe.gov/center/stewlink2.asp)

7. *CLU-IN: Hazardous Waste Clean-Up Information* Website, U.S. Environmental Protection Agency, Technology Innovation Office. (URL: http://www.clu-in.org/)

8. *"Technology Needs",* Nevada Test Site, U.S. Department of Energy. (URL: http://www.nv.doe.gov/nts/default.htm)

9. Office of Legacy Management, U.S. Department of Energy, Website. (URL: http://www.gjo.doe.gov/)

10. *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences*, U.S. DOE Office of Environmental Management, 1997. (Report No. DOE/EM-0319) (Full text available at: http://legacystory.apps.em.doe.gov/index.asp. Click on preferred option in table at center of page.)

* Abstract and ordering information available from National Technical Information Service (NTIS). Telephone: 1-800-553-6847. Website: http://www.ntis.gov/ (Search by order no. Please note: Items that are unavailable via the Website might be obtained by phoning NTIS.)

18. MEDICAL SCIENCES

The Department of Energy is interested in innovative research involving medical technologies to facilitate and advance the current state of diagnosis and treatment of human disorders. Principles of physics, chemistry, and engineering are being employed to advance fundamental concepts dealing with human health, to utilize the study of molecular interactions for a better understanding of organ function, and to develop innovative biologics, materials, processes, implants, devices, and informatics systems for the prevention, diagnosis, and treatment of disease and for improving human health.

The DOE Medical Sciences program covers a broad range of energy-related technologies, including nuclear medicine and advanced imaging instrumentation. With respect to nuclear medicine, this topic addresses the development of: (1) radiopharmaceuticals as radiotracers to study *in vivo* chemistry, metabolism, cell communication, and gene expression in normal and disease states, and as therapeutic agents; and (2) new radionuclide imaging systems.

The DOE Advanced Medical Instrumentation program seeks to capitalize on the unique physical sciences and engineering capabilities at the DOE's national laboratories to develop new technologies that will have a significant impact on human health. Within this area, this topic addresses the development of power sources for implantable devices.

Grant applications are sought only in the following subtopics:

a. Radiopharmaceutical Development for Radiotracer Diagnosis and Targeted Molecular Therapy— Grant applications are sought to develop: (1) radiolabeled compounds that could have applications as radiotracers for radionuclide imaging technologies such as positron emission tomography and single photon emission computed tomography; (2) improved and simplified production of radiolabeled compounds through the use of mini-accelerator technology or automated radiochemical analysis/synthesis techniques; and (3) radiopharmaceuticals for targeted molecular therapy. Of particular interest are radiochemical, synthetic, and combinatorial molecular engineering approaches. All efforts should ultimately result in a product for nuclear medicine use.

Questions - contact Prem Srivastava (prem.srivastava@science.doe.gov)

b. Advanced Imaging Technologies—Grant applications are sought for new, sensitive, high-resolution instrumentation for radionuclide imaging. The instrumentation should advance the application of radiotracer methodologies for imaging molecular biological functions, including cell communication and gene expression *in vivo*. Areas of interest include the development of: (1) new detector materials and detector arrays for both positron emission and single photon emission computed tomography; (2) software for rapid image data processing and image reconstruction; (3) hybrid imaging systems that combine nuclear medicine imaging in novel ways with CT, MRI, mammography, ultrasound, etc., and (4) methods of integrating *in vitro* and *in vivo* instrumentation technologies for real time molecular imaging of biological function and for drug development.

Questions - contact Peter Kirchner (peter.kirchner@science.doe.gov)

c. Development of Non-Photovoltaic Biological Power Sources for Implantable Devices—Grant applications are sought to develop innovative, unconventional power sources to operate medical devices that are implanted inside the human body. The power sources could be biological or mechanical in design, and could include biomotion or *in vivo* biochemical reactions. Because current photovoltaic power sources contain metals and other highly toxic components, these sources must be carefully encased before implantation; therefore, the development of a small implantable biological power source would alleviate concerns about implantation safety and disposal. Grant applications must provide calculations to demonstrate that the proposed device will supply the energy required to power an implantable device and meet any biocompatibility requirements of the Food and Drug Administration. Some of the DOE national laboratories have developed considerable expertise in this research area and are available for possible collaboration.

Questions - contact Dean Cole (dean.cole@science.doe.gov)

References:

1 2nd Annual National Academies Keck Future Initiative Conference: *Designing Nanostructures at the Interface Between Biomedical and Physical Systems,* Irvine, California, November 18-21, 2004 Website. (URL: http://www7.nationalacademies.org/keck/Keck_Futures_Nano_Conferences_Focus_Groups.html)

2 Smith, H. O., et al., *Biological Solutions to Renewable Energy*, Summer 2003. (Full text available at: http://www.nae.edu/nae/bridgecom.nsf/weblinks/MKUF-5NTMX9?OpenDocument)

3 Nuclear Science (NSS/MIC) 2002 IEEE Symposium and Medical Imaging, Conference, Proceedings, IEEE, 2002. (CD-ROM 2002) (ISBN: 0-7803-76374) (IEEE Product No.: CH37399C-TBR)

4 Bushberg, J. T., et al., The Essential Physics of Medical Imaging, Lippincott Williams & Wilkins, November 2001. (ISBN: 0-6833-01187) (Available to purchase at: http://www.medbookstore.com/books/ProductDetails.asp?CatalogID=689978)

5 Hendee, W. R. and Ritenour, R. E., Medical Imaging Physics, 4th ed., New York: Wiley- Liss, June 2002. (ISBN: 0-4713-82264) (Available to purchase at: http://www.medbookstore.com/books/ProductDetails.asp?CatalogID=3499256)

6 Feinendegen, L. E., et al., eds., Molecular Nuclear Medicine, Springer-Verlag, January (ISBN: 3-5400-01328) (Available to purchase at: http://www.medbookstore.com/books/ProductDetails.asp?CatalogID=4571318)

7 Kowalsky, R. J. and Falen, S. W., Radiopharmaceuticals in Nuclear Pharmacy and Nuclear Medicine, 2nd ed., Washington, DC: American Pharmacists Association, July 2004. (ISBN: 1-5821-20315))

8 Wahl, R. L., ed., Buchanan, J. W., asso. ed., Principles and Practice of Positron Emission Tomography, Philadelphia, PA: Lippincott Williams & Wilkins, August 2002. (ISBN: 0-7817-29041) (Publisher's description and ordering information available at: http://www.lww.comproduct/?0-7817-2904-1)

9 "Supplementary Information," at Website for DOE Office of Science, Notice 03-14: *Radiopharmaceutical and Molecular Nuclear Medicine Science Research - Medical Applications Program*. (Available at: http://www.sc.doe.gov/grants/Fr03-14.html. Scroll down page to text under "Supplementary Information.")

10 Vera, D. R. and Eckelman, W. C., "Receptor 1980 and Receptor 2000: Twenty Years of Progress in Receptor-Binding Radiotracers," *Nuclear Medicine and Biology*, 28(5):475-476, July 2001. (ISSN: 0969-8051) (Abstract and ordering information available at: http://www.sciencedirect.com/. Under "Search for a title", enter *Nuclear Medicine and Biology*. Continue search using information given above.

11 Welch, M. J. and Redvanly, C. S., eds., Handbook of Radiopharmaceuticals: Radiochemistry and Applications, Hoboken, NJ: John Wiley & Sons, January 2003. (ISBN: 0-4714-95603) (Table of contents and ordering information available at: http://www.wiley.com/WileyCDA/WileyTitle/productCd-0471495603.html)

12 Cherry, S. R., et al., Physics in Nuclear Medicine, 3rd ed., Philadelphia, PA: W.B. Saunders, June 2003. (ISBN: 0-7216-8341X)

13 Sandler, M. P., et al., eds., Diagnostic Nuclear Medicine, 4th ed., Philadelphia, PA: Lippincott Williams & Wilkins, October 2002. (ISBN: 0-7817-32522) (Publisher's description and ordering information available at: http://www.lww.com/product/?0-7817-3252-2)

OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

19. WIND ENERGY TECHNOLOGY DEVELOPMENT

For over 25 years the Wind Energy Program, one element of the U.S. Department of Energy (DOE) Wind and Hydropower Technology Program (WHTP) under the Office of Energy Efficiency and Renewable Energy (EERE), has been a central component of the Nation's efforts to advance wind energy technology, both for

large utility scale and smaller distributed wind technologies. In close partnership with industry and the national laboratories, the Wind Program has worked to expand the technology base for wind energy as well as to foster innovation, culminating in some of industry's leading products today.

Utility-scale wind turbines are currently capable of producing electricity at 4.5 to 5.0 cents/kWh at Class 4 wind sites, which are broadly available across the United States. However, these turbine designs are not well suited to low wind sites and have only limited potential to achieve lower costs of energy. Moreover, the cost of materials for wind turbine components has continued to escalate in recent years, creating more barriers to wind energy market expansion. It will be a substantial challenge to design, manufacture, and install wind turbines that are low in cost and yet rugged enough to withstand 20 to 30 years of operation in weather that is often severe.

Proposed projects that involve the participation of a DOE national laboratory must obtain approval from the laboratory prior to submission, and provide evidence of that approval in the grant application.

Grant applications are sought only in the following subtopics:

a. Small Vertical Axis Wind Turbines—Vertical axis wind turbines (VAWTs) have potential to play a role in energy production in residential and industrial applications. Compared to horizontal axis wind turbines (HAWTs), VAWTs have a slight disadvantage in theoretical efficiency. However, this disadvantage may be offset by advantages in operation and maintenance: most VAWT drivetrain components are near the ground, and the VAWT can accept wind from any direction. Moreover, it is possible that the technology advances that have been applied to HAWTs over the past decade could be applied to VAWTs as well, resulting in turbines that could be competitive with HAWTs in the marketplace. Grant applications are sought for advanced VAWT designs that utilize novel materials and innovative design features to achieve improved performance and reduced cost of energy relative to designs of the past. Areas of interest include the use of composite materials for the blades and/or tower, implementation of a free-standing pedestal tower to eliminate the need for guy cables, and the use of active aerodynamics to enhance performance and/or limit blade loads. Phase I should consist of a concept study and/or prototype evaluation to investigate the benefits of incorporating the proposed technology into a new VAWT design. The Phase I report should summarize the relative advantages and disadvantages of the newly designed VAWT in comparison with current-generation HAWTs. Note that the focus of this topic is on VAWT technology for distributed applications that are less than 100kW; grant applications dealing with megawatt-scale VAWT designs are not of interest and will be declined.

Questions - contact Dennis Lin (dennis.lin@hq.doe.gov)

b. Remote Sensing Systems for Resource Assessment— The evaluation of potential sites for wind turbines requires a thorough assessment of the inflow wind resource. Historically, wind data collection has relied on the installation of meteorological towers instrumented with cup anemometers to characterize the wind potential. As wind turbines have significantly increased in size and complexity, the cost of installing these towers at turbine hub heights (greater than 80 meters) has become prohibitive. In addition to the average wind speed, the "quality" of the wind resource (including turbulence, coherence, shear and stability) has become an important criterion in evaluating the potential performance of advanced machines. Therefore, grant applications are sought to develop a new, low cost, remote-sensing measuring system. Approaches of interest should utilize complimentary multiple sensor technology, provide wind assessments to at least 200 meters with a high data capture ratio, and measure associated vertical temperature and turbulence distributions. These data will be used for operational, regional mesoscale modeling and validation, and as input for better turbine designs and long-term resource assessments at elevated tower heights.

Questions - contact Dennis Lin (dennis.lin@hq.doe.gov)

c. Manufacturing and Assembly—New tools, methods, and designs are needed to reduce manufacturing cost, improve speed of fabrication, and improve the quality of both large- and small-scale wind turbines. Some utility scale wind turbines have become so large that transportation limitations are driving final, onsite assembly costs. With respect to small, distributed wind turbines, most are made in limited production runs, with varying component/subsystem suppliers and a high degree of customization. Therefore, for both large- and small-scale wind turbines, grant applications are sought for to develop advanced approaches for assembly, component manufacturing, materials or fiber processing, materials handling, and turbine installation and erection. Approaches of interest may address either central manufacturing facilities or onsite manufacturing, and include the development of techniques to enable high volume production as well as techniques for manufacturing key components, including blades, power electronics, and towers. For example, hybrid composite/steel structures have the potential to replace current tower designs which are relatively expensive and sometimes lack aesthetic appeal. Grant applications must: (1) demonstrate that the proposed approach will help reduce the cost of assembly and installation, while having a limited impact on overall capital cost; and (2) include an economic analysis that accounts for such long-term implications as maintenance, refurbishment, replacement, and recycling.

Questions - contact Dennis Lin (dennis.lin@hq.doe.gov).

Subtopic a References:

1 Sandia Laboratories Staff, 1990, "Selected Papers on Wind Energy Technology," SAND90-1615, Sandia National Laboratories, Albuquerque, NM. (Full text available at: http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/1990/901615.pdf)

2 FloWind Corporation, 1996, "Final Project Report: High-Energy Rotor Development, Test and Evaluation," SAND96-2205, Sandia National Laboratories, Albuquerque, NM (Full text available at: http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/1996/962205.pdf)

Subtopic b References:

1. Grady, B.W., et al., "Wind Measurements with High Energy 2μm Coherent Doppler LIDAR", Proceedings 22nd International Laser Radar Conference 12-16 July, 2004 in Matera, Italy, European Space Agency: Paris, ESA SP-561. (URL: http://adsabs.harvard.edu/abs/2004ilrc.conf..801B)

2. Pichugina, Y.L.; Banta, R.M.; Kelley, N.D. "Application of High-Resolution Doppler Lidar Data," Proceedings 2nd Symposium on Lidar Atmospheric Applications, American Meteorological Society, January 8-13, 2005, San Diego, CA. (Full text available at: http://ams.confex.com/ams/pdfpapers/86691.pdf)

3. Pichugina, Y.L.; Banta, R.M.; Brewer, W.A., "Vertical Profiles of Velocity Variances and TKE Using Doppler-Lidar Scan Data." Proceedings of 17th Symposium on Boundary Layers and Turbulence, American Meteorological Society, May 21-25, 2006, San Diego, CA. (Full text available at: http://ams.confex.com/ams/pdfpapers/111195.pdf)

Subtopic c References:

1. Sherwood, K., "Blade Manufacturing Improvement Project: Final Report," Sandia National Laboratories, SAND2002-3101, Albuquerque, NM. (Full text available at: http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/2002/023101.pdf)

2. "The U.S. Small Wind Turbine Industry Road Map: A 20-Year Industry Plan for Small Wind Turbine Technology," American Wind Energy Association, 2002 National Renewable Energy Laboratory, Golden, CO. (Full text available at: http://www.awea.org/smallwind/documents/31958.pdf)

20. TRADITIONAL ENERGY EFFICIENT LIGHTING TECHNOLOGIES

Representing more than 20% of the energy consumed in US buildings, lighting is still produced by technologies developed during periods of our history where conservation and environmental concerns were quite different than they are today. Although developed in its present form more than 100 years ago, the ubiquitous yet inefficient incandescent lamp is still found in widespread use throughout the world. A number of nations (including Brazil, Venezuela, Australia, New Zealand, Germany, Belgium, and Canada) and several States (including California, Connecticut, and New Jersey) have contemplated or passed legislation to phase out incandescent lamps in favor of compact fluorescent alternatives by 2010. However, such aggressive proposals have not gathered more support for a variety of reasons: consumer safety, environmental concerns of mercury, characteristic emission spectrum, starting behavior, replacement costs, and difficulty in dimming. While a number of technical advancements in recent years have contributed to important increases in the performance of traditional light sources and components used in commercial and residential buildings, there is still ample opportunity for additional improvements. These improvements also must address the need to reduce the amount of mercury (Hg), which is required to promote starting and efficient operation in most common lamps manufactured today. The lamp types that contain Hg include: linear fluorescent (LFL), compact fluorescent (CFL), high intensity discharge (HID) including metal halide, ceramic metal halide, high pressure sodium, and mercury vapor, and other types of discharge lamps such as mercury short arc, mercury xenon short arc lamps, capillary, and neon. Hg content in these lamps ranges widely, from a just few milligrams per lamp to 1,000 milligrams per lamp.

Grant applications are sought only in the following subtopics.

a. High Intensity Discharge (HID) Lamps—Today, the HID segment of the lighting market represents about 14% of the lamps sold to the commercial sector and close to 30% of those sold in the industrial sector. As technical improvements to HIDs evolve, they are expected to produce improvements in the efficiency of selected products, increase life-cycle cost effectiveness, and expand the applicability of HID lighting systems to markets currently dominated by much less efficacious sources, including incandescent and halogen lamps. Grant applications are sought to accelerate improvements to HID system energy efficiency and to the suitability of HIDs to applications presently dominated by less efficacious sources. Of particular interest are opportunities identified by the DOE in a report of an HID workshop. These opportunities include: re-strike and instant on; dimming (continuous to 30%); spectral issues including coatings, IR management, diagnostics; ballast designs including lumen maintenance and color shift; fill materials and chemistry; electrode materials, coatings, and lamp envelope; and HID lamp system optimization. Any other grant application that seeks to advance HID lamps or system performance consistent with the objectives described in the workshop report, such as reductions in mercury content of specific HID product categories, also would be of interest.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

b. Fluorescent Lamp and Phosphor Technology— Fluorescent lighting – which produces 60% of the light used in commercial building, yet consumes only 40% of the lighting energy budget – represents another excellent target of energy efficiency improvement. Modern fluorescent lamp systems, especially T-8 linear fluorescent lamps (LFLs) used with electronic ballasts and solid-state controls, are good at producing very high light quality with acceptable energy efficiency over an extensive lifetime. Compact fluorescent lamps (CFLs) are not far behind. However, even the best of today's T-8 LFLs convert only about 28% of consumed power into visible radiation. Mostly, this inefficiency is attributed to electrode losses (~16%), unwanted infrared emissions (~37%), and other discharge column loses (~18%) including small amounts of ultraviolet emission. Grant applications are sought for innovations and novel approaches to overcoming these losses while simultaneously reducing or eliminating mercury, resulting in advanced fluorescent lamps with even better efficacy than today's products.

Grant applications also are sought to extend the use of phosphor technology in general illumination beyond the current product mix of fluorescent lamps. Approaches of interest include: (1) the up-conversion of infrared radiation into visible light; and (2) the development of nanocrystalline structures that can alter emissive wavelengths or certain light capture mechanisms, which may provide potential use in semiconductor devices or other types of discharge lighting or photvoltaics; or any other concept where advanced phosphor technology could positively impact the DOE mission. Grant applications should identify how the technical approach will lead to increased phosphor efficiency or range of application.

Grant applications that seek to significantly reduce or eliminate mercury as a key ingredient to fluorescent lamp designs, while maintaining current efficiency standards, are especially relevant and encouraged under this subtopic.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

c. Advanced Ballasts and Controls—Many new control and solid-state components have become widely available, and these components could have a positive and lasting impact on powering light sources of conventional designs. Improvements such as advanced dimming ballasts for LFLs or HIDs are now capable of simultaneously reducing power to lamps and conserving energy, therby providing a more useful, flexible source of illumination with no compromise to performance or life. Moreover, new controls and sensors offer the opportunity for lighting designers to include the harvesting of sunlight in buildings. Grant applications are sought for: (1) innovations associated with advanced control methodologies, in order to expedite the integration of lighting controls with other building systems including daylight harvesting; and (2) performance advancements to the ballasts and power supplies used by all forms of discharge lighting. Special consideration will be given to approaches that are cost competitive with the devices or system being replaced and are consistent with the recommendations of the DOE and other energy conservation organizations and regulators.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

d. Incandescent Lamps—Thomas Edison developed the first incandescent lamp using a carbonized sewing thread taken from his wife's sewing box. His first commercial product used carbonized bamboo fibers and operated at about 60 watts for about 100 hours and had an efficacy of approximately 1.4 LPW. Today, incremental improvements have raised the efficacy of current 120-volt, 60-watt incandescent lamp to about 15 LPW for products with an average lifetime of 1,000 hours. Although this increase is impressive, it has been suggested that technical advancements in the materials used for manufacturing incandescent lamps could increase lamp efficacy by a factor of two or more, by decreasing unwanted infrared emissions in favor of useful visible light. Therefore grant applications are sought to develop new and advanced materials technologies leading to new incandescent lamp designs that will survive the extreme environment of today's incandescent products for durations of 1,000 hours or more. Approaches of interest include the development of: (1) photonic structures or even novel materials systems that could selectively and favorably alter the emissivity of the incandescing surfaces, (2) different fill gas materials that interact with the incandescing material to yield a net

increase in visible radiation over unwanted IR, and (3) novel coatings applied to the inside surface of the bulb, which could cause a similar favorable interaction (e.g., up-converting phosphors or other complex materials). In addition to efficiency increases, grant applications must demonstrate that the incandescent lamp advancement would have no adverse impact upon the prospects of continuing to manufacture a wide range of inexpensive products using the existing 100-year plus technology base and cumulative tooling investment. This requirement would permit the inexpensive manufacture of lamps that are competitive with other lighting technologies just beginning to emerge.

Questions - contact Rick Orrison (Richard.orrison@hq.doe.gov)

References:

1 "Mercury Use in Lighting", Northeast Waste Management Officials' Association, 2006. (Full text available at http://www.newmoa.org/prevention/mercury/imerc/FactSheets/lighting.cfm)

2 Frequently Asked Questions: Information on Compact Fluroescent Light Bulbs (CFLs) and Mercury, August 2007. EnergyStar.gov. (Full text available at: http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf)

3 "Where You Live: Regions, States and Tribes", Environmental Protection Agency Website: (URL: http://www.epa.gov/epaoswer/osw/regions.htm)

4 "High Intensity Discharge Lighting Technology Workshop Report", November 15, 2005, Washington, DC, ICF Consulting, January, 2006. (Full text available at: http://www.eere.energy.gov/buildings/info/documents/pdfs/hid_report_111505.pdf)

5 "Sidelighting Photocontrols Field Study", HMG Final Report to the Southern California Edison Company, Pacific Gas & Electric Company, Northwest Energy Efficiency Alliance, 2004. (Download full text at: http://www.h-m-g.com/Projects/Photocontrols/sidelighting_photocontrols_field.htm)

21. GEOTHERMAL TECHNOLOGIES

Generation of electricity from geothermal energy typically involves drilling wells into naturally-heated subterranean aquifers, and then expanding a hot fluid – either the fluid produced directly from those wells or a secondary fluid heated by the directly-produced fluid – through a turboexpander that drives an electric generator. While commercial geothermal power projects are now successfully operating in five states, further development of the nation's geothermal resources would benefit from improved technology for drilling wells into geothermal aquifers, producing fluids from them, and generating electricity from those fluids.

Grant applications are sought only in the following subtopics.

a. Non-Rotating Drilling for Geothermal Energy Development—The drilling of wells represents a significant cost for geothermal development. Rock formations containing geothermal aquifers are typically volcanic in nature: hot, hard, crystalline, and fractured. With current drilling techniques, energy is transmitted to the rock face by drill-string rotation or by pumping drilling fluid to power a downhole mud motor. Cuttings are removed from the borehole via fluid circulation. Wear of the drill bit requires frequent removal of the drill string from the hole (so-called "trips") and replacement of the bit. Rock reduction (the process of breaking down the rock) is commonly accomplished by crushing with roller bits or shearing using drag bits.

Improvements in the rock reduction could increase the efficiency of geothermal well drilling. Therefore, grant applications are sought to develop innovative rock reduction systems for drilling geothermal wells.

Approaches of interest must: (1) be capable of creating borehole diameters larger than 6½ inches, (2) be able to operate at temperatures up to 225°C and downhole pressures up to 10,000 psi, (3) provide a rate of penetration (ROP) greater than 80 feet per hour in hard rock such as Sierra White Granite, and (4) allow for adding more than 800 feet of depth per trip (better than emerging polycrystalline diamond compact (PDC) bit technology). Proposed systems may employ a rotating drill string, but the rotation shall not be used to transmit energy to the rock by imparting torque to a drill bit; however, proposed systems may use rotation and hydraulic transmission of energy for rock reduction in non-traditional, innovative ways. Grant applications must describe the rock reduction technology being proposed and must also explain how rock removal and well control will be accomplished as part of the drilling process.

Questions - contact Raymond LaSala (Raymond.lasala@hq.doe.gov)

b. Aphron-Based Well Construction Fluids—Two significant problems in geothermal well construction are the need for light drilling fluids (with density less than water) and light cements. In the past, methods to reduce the density of these materials have included mixing-in air, nitrogen, perlite, or other low-density solids (glass beads, etc.). However, problems with these approaches include instability (bubbles collapse or expand), increased cost, and reduced strength. Recently, the use of aphrons (microbubbles) has shown promise for this application. However, considerable development will be needed to make this concept work at high temperatures (225° C). Therefore, grant applications are sought to develop innovative aphron-based ways of making light (density less than water), high temperature (225°C), cheap drilling fluids and cements that can provide a long lifetime under geothermal conditions.

Questions - contact Raymond LaSala (Raymond.lasala@hq.doe.gov)

c. High Temperature Submersible Well Pump Materials—The need for environmentally-clean alternative energy is increasing the need for localized geothermal power production near power consumers, especially near major cities and factories. The development of reliable submersible electrical geothermal pumps is critical to the development of widespread geothermal power production. Therefore, grant applications are sought for new designs and materials for high-temperature (300 to 450º F) electric submersible pumps for geothermal applications. The pumps must require no maintenance over a 5 to 10 year operating life in a hot, corrosive, geothermal brine environment, which may contain CO_2, H_2S, chloride, calcium, silica, and entrained sand or other materials. In addition, the pumping system should include a number of specific features: improved electrical power cables that are easily spliced and terminated in the field; solders for making connections; mechanical rotating face seals, shaft seals, and O-rings; and wear-resistant bearings.

Questions - contact Raymond LaSala (Raymond.lasala@hq.doe.gov)

d. Air-Cooled Condenser Enhancements for Geothermal Power Plants—When lower-temperature geothermal resources are used to generate electricity, the most cost effective energy conversion systems typically use some sort of binary power cycle. In this power cycle, the geothermal brine is not exposed to the environment – all of it is returned to the subsurface reservoir to be re-heated. Because geothermal resources often are found in arid regions of the U.S. – and consequently lack an adequate source of surface or near-surface water for use in an evaporative heat rejection system for the power plant – the binary-cycle working fluid (commonly a refrigerant such as isobutane, isopentane, R-134a, etc.) is condensed (nominally, at 30° to 40°F above the ambient air temperature) in an air-cooled heat exchanger, with heat rejected to the ambient dry bulb temperature. The air-cooled heat exchanger typically consists of multiple rows of radially-finned tubes (1-inch

outside diameter) with either forced or induced airflow past the outside of the tubes. Inside the tubes, the vapor of the binary-cycle working fluid, having exited the turbine, is desuperheated and condensed. Outside the tubes, the external fins increase the surface area exposed to the air-flow, which is needed because of the low heat transfer coefficients on the air side.

These air-cooled condensers are a significant contributor to the cost of generating electrical power, because of their size and associated capital cost, and because of the fan power needed to circulate air past the condenser tubes. (The condensers are large because: (1) these plants reject a significant portion (up to ~90%) of the heat extracted from the geothermal brine; and (2) air is a poor heat transfer fluid that produces low heat transfer film coefficients.) In addition, because of the relatively low heat source temperatures, performance of these plants is very sensitive to changes in the heat sink (ambient) temperature. Typically, the air-cooled condensers in a geothermal binary plant are designed for the average annual air temperature at a given locale; during the hotter portions of the year, it is not unusual for a plant's output to be less than two-thirds of the rated capacity. Therefore, grant applications are sought to improve the performance and economics of air-cooled condensers for binary-cycle geothermal power plants. Approaches of interest include, but are not limited to:

- Enhancing the airside heat transfer coefficient by means of extended or otherwise engineered surfaces. Potential innovations for achieving the enhancements include small transverse fins (tabs) on the major fins, unique fin types such as pleated fins with flow through small holes in the fins, or vortex generators to direct flow into the wake region. These surface modifications could be used to repeatedly disrupt the air boundary layer on the fin surface, or to improve the air flow distribution across the fin surface (to take advantage of the increased surface area). However, it must be demonstrated that the benefit in heat transfer is not offset by an increased pressure drop across the airflow path.

- Decreasing parasitic fan power by minimizing the pressure drop. However, constant heat transfer performance must be maintained, either by improving the airside flow path or by innovations that allow the fan to move more air with less energy.

- Reducing the effective heat sink (ambient) temperature to more closely approach ambient wet-bulb temperature. In an arid region, the source of water for this cooling could be the cooled geothermal brine leaving the plant. Issues to be addressed include the availability and quality of water and the potential for fouling or corrosion due to carryover of moisture and dissolved solids in the air contacting the condenser tubes.

- Employing a different heat exchanger design, such as one using microchannel technology, that is compatible with other aspects of geothermal power plant operation and maintenance.

The scale of existing air-cooled binary plants varies from ~0.5 MW to 15 MW (electrical) net output. Other basic information on geothermal plants can be found on the Department of Energy Geothermal Technologies Program web site, http://www1.eere.energy.gov/geothermal/, as well as the Geothermal Energy Association's site, http://www.geo-energy.org/. More detailed information on the power plants is provided in DiPippo's *Geothermal Power Plants*.

Questions - contact Raymond LaSala (Raymond.lasala@hq.doe.gov)

Subtopic a References:

1. Knott, D., "Deep Thoughts on Drilling Technology," *Oil & Gas Journal*, p.29, June 10, 1996. (ISSN: 0030-1388)

2. Glowka, D., Recommendations of the Workshop on Advance Geothermal Drilling System, Sandia National Laboratories, December 1997. (Report No. SAND97-2903) (Full text available at: http://www.osti.gov/energycitations/basicsearch.jsp. Search by Report No.)

Subtopic b References:

1 Schaneman, B.D., et al, "Aphrons Technology – A Solution, American Association of Drilling Engineers", AADE-03-NTCE-41. (Full text available at: www.aade.org/TechPapers/2003Papers/Lost%20Circulation/AADE-03-NTCE-41-Schaneman.pdf)

2 "Enhanced Wellbore Stabilization and Reservoir Productivity with Aphron Drilling Fluid Technology", Oil & Natural Gas Projects, National Energy Technology Laboratory Website. (Full text available at: http://www.netl.doe.gov/technologies/oil-gas/NaturalGas/Projects_n/EP/DCS/DCS_A_42000WellboreAphron.html)

Subtopic c Background References:

1 B.L.Hopper, "Reliability Improvements in Deepsetting Lineshaft Pumps for Geothermal Service", *Geothermal Resources Council*, Trans. V 11, Oct. 1987 pp419-423 (ISSN: 0193-5933)

2 Vandevier, J.E., "Commercial Uses of Geothermal Heat"Electrical submersible pumps in geothermal environments, Geothermal Resources Council Special Reports, June, 1980, pp113-116 (Available at: http://www.geothermal.org/result.php?CategoryID=3&Title=&Keywords=&Author=Vandevier&Source=&Volume=&Number=&PublicationYear=1980&SUBMIT=Search)

3 Lund, J.W. , Culver, G. and Lienau, P.J., "Groundwater Characteristics and Corrosion Problems Associated With the Use of Geothermal Water in Klamath Falls", Oregon, *Geothermal Resources Council*, Trans, Vol 1, May 1977, pp197-198 (ISSN: 0193-5933)

Subtopic d References:

1 Kutscher, C.F.; Gawlik, K., "Heat Exchanger with Transpired, Highly Porous Fins". 2002. U. S. Patent No 6,378,605 B1. 22 pp.; NREL Report No. 32290. (Abstract available at: http://www.patentstorm.us/patents/6378605.html)

2 M. S. Sohal and G. L. Mines, "Enhancement of Air Cooled Condenser Performance," Proceedings of Geothermal Resources Council Annual Meeting, Morelia, Mexico, October 12-15, 2003. (ISSN: 0193-5933)

3 DiPippo, R, "Geothermal Power Plants: Principles, Applications and Case Studies", Elsevier Ltd, Oxford U.K., 2005. (ISBN 1-8561-74743)

4 "Microchannel Heat Exchangers," ACEEE, 2004. (Full text available at: http://www.aceee.org/store/proddetail.cfm?ItemID=381&CategoryID=7)

22. HYDROGEN, FUEL CELLS, AND INFRASTRUCTURE TECHNOLOGIES

President Bush announced the Hydrogen Fuel Initiative (HFI) in his State of the Union address in January 2003. The objectives of this Initiative are to reduce our dependence on imported oil, reduce greenhouse gas emissions, and reduce air emissions.

Achieving these objectives will require cost effective and energy efficient hydrogen production technology, in order to enable the widespread use of hydrogen for transportation and stationary power. The DOE target for hydrogen production cost is $2.00- $3.00 per gallon of gasoline equivalent at the pump (untaxed); this target would permit hydrogen fuel cell vehicles to compete with gasoline and hybrid gasoline vehicles on a cost per mile basis. Subtopics a and b are concerned with hydrogen production technology.

Because hydrogen is used as the energy carrier in fuel cell applications (e.g., fuel cell vehicles and stationary power), the further development of fuel cells and fuel cell components – for both Solid Oxide Fuel Cells (SOFCs) and Polymer Electrolyte Membrane (PEM) fuel cells – also will contribute to HFI objectives. SOFCs operate at very high temperatures (around 800°C); therefore, they can reform fuels internally, which enables the use of a variety of fuels including biomass-derived fuels. PEM fuel cells require the development of high quality, inexpensive bipolar plates for planar fuel cell stacks. Subtopics c and d are concerned with these fuel cell technologies.

Grant applications are sought only in the following subtopics.

a. Hydrogen from Waste—An estimated 10 quads (1 quad = 10^{15} Btu) of hydrogen fuel could be needed in the U.S. from renewable resources in the 2030 to 2050 timeframe.[4] These resources include waste, such as municipal solid waste (MSW) or animal wastes. The amount of MSW that is both suitable and potentially available for hydrogen production is on the order of 100-150 million tons per year.[5] Based on available technologies, one would expect a yield of 6-10% by weight of hydrogen or 6-15 million tons of hydrogen (0.7-1.5 quads). This could be a meaningful source of hydrogen. Therefore, grant applications are sought to develop technology for producing pure hydrogen from MSW or animal wastes. Of particular interest are technologies that have the potential of producing a minimum of 5,000 kg per day of hydrogen from these waste resources for less than $3.00 per gallon of gasoline equivalent. Medium scale hydrogen production technologies (5,000-50,000 kg/day), which could use regional distribution networks, also are of interest. The Phase I project must include a detailed analysis of the process economics for the proposed technology, estimates of energy use and environmental emissions associated with the production of hydrogen, and a technology development plan. DOE's H2A Production spreadsheet tool[6] should be used to estimate the process economics, which cannot depend on the receipt of tipping fees for the MSW.

Questions - contact Arlene Anderson (Arlene.anderson@hq.doe.gov)

b. Development of a Sulfur Dioxide Electrolyzer for the Hybrid Sulfur Hydrogen Production Process— The production of hydrogen from fission power can provide high efficiency and energy security with almost no carbon dioxide emissions. Utilizing heat from the nuclear plant, the hybrid sulfur process (HyS) produces hydrogen in a thermochemical/ electrochemical water-splitting cycle. However, the efficacy of the electrolysis step of the HyS process has yet to be optimized. In addition, in a recent test of an electrolyzer at Savannah River National Laboratory (SRNL), sulfur formation was noted on the cathode, thereby underscoring the need to understand and control sulfur dioxide crossover to the cathode.

Grant applications are sought to develop materials or provide analyses to address practical issues of the electrochemistry of the HyS cycle, leading to improved efficiency, electrolysis at 500 mA/cm²at 600 mV at a temperature of 90-120°C, and reduced sulfur formation. Approaches of interest include the development of: (1) cathode catalysts and structures that retard the formation of reduced sulfur species (i.e., H_2S and elemental sulfur); (2) anode catalysts and electrodes that minimize the stoichiometric requirements of water and SO_2; (3)

high temperature (100-140°C) proton exchange membranes that are highly conductive, resistant to SO_2 crossover, and operational with very low water content; (4) methods to manage the mass transfer limitations of water and sulfur dioxide; and (5) techniques to control or eliminate sulfur dioxide membrane crossover. Also of interest is the development of analysis techniques for selecting system features – including electrolyzer stack designs, electrolyzer voltage requirements, materials of construction, sulfuric acid concentration (for interface with downstream processes), operating temperature, and operating modes – in order to optimize utilization/electrochemical efficiency, performance, cost, and/or reliability.

Questions - contact Carl Sink (Carl.sink@hq.doe.gov)

c. Bio-Fueled Solid Oxide Fuel Cell—Fuels derived from biomass, when integrated with state-of-the-art solid oxide fuel cell (SOFC) technology, provide a substantial opportunity to reduce the burden on the current electrical distribution system, through greater availability of localized power generation. The use of bio-derived fuels in distributed generation applications also would reduce the growth in the demand for natural gas, as well as enhance grid stability. Given the dispersed distribution of biofuel resources, this strategy would reduce the transportation cost of delivering fuel to distributed power generation locations, particularly for liquefied natural gas. SOFCs, which feature high efficiency (>45%) in small (kW class) sizes, are an ideal power generation technology for this application. Moreover, SOFCs produce very low emissions (e.g., <0.5 ppm NO_x), due to the much lower operating temperatures compared to conventional combustion-based technologies. The Department of Energy through its Solid State Energy Conversion Alliance has determined that a high-volume system cost of $400/kW is achievable, which would make SOFCs competitive in the distributed generation market.

Grant applications are sought to develop, characterize, and identify promising system concepts for bio-fueled SOFCs in distributed generation applications. The system should include a fuel processor that reforms a biomass-derived product or bio-fuel into a fuel for a 3-30 kW-scale distributed SOFC system. An emphasis on bio-fuels, which are suitable for an SOFC and derived from sources (such as cellulosic biomass, agricultural residues, or municipal solid waste) that do not compete with food supply, is preferable. Current technologies that convert a biomass-derived product or bio-fuel should be assessed for compatibility with current SOFC systems. Novel pathways should also be considered. Distributed energy systems on the kW-scale that process biomass directly will likely be too costly and should not be considered.

In Phase I, a conceptual system design should be developed and analyzed to assess performance, and an assessment of the commercial viability of the proposed approach should be conducted. Particular emphasis should be placed on the fuel processing subsystem required to produce a fuel suitable for an SOFC stack, and on the synergistic integration of the fuel processor and the stack. Phase II should involve the development, design, fabrication, and testing of the fuel processing subsystem using biomass as the fuel. Fuel processor efficiency should be measured, and a pathway for meeting the DOE 2011 Distributed Energy System efficiency target of 40% should be identified. Phase III should focus on system demonstration.

Questions - contact Jason Marcinkoski (Jason.marcinkoski@hq.doe.gov)

d. Manufacturing of Bipolar Plates— Polymer Electrolyte Membrane (PEM) fuel cells can be used for a variety of electricity needs, from replacing batteries in small appliances to powering homes, offices, and vehicles. PEM fuel cells with planar fuel cell stacks use bipolar plates that serve both as a conduit for the gas flow field and as an electric current collector. Channels on the side of the bipolar plate carry reactant gas from the place where it enters the fuel cell to the place where it exits. Bipolar plates must be low cost, lightweight, strong, gas-impermeable, and electron-conducting. Therefore, grant applications are sought to develop and demonstrate metal bipolar plate manufacturing processes that: (1) maintain the high tolerance requirements of a PEM fuel cell for flow field dimensions, plate flatness, and plate parallelism, as needed for ferritic and austenitic based bipolar plates; and (2) are scaleable to high-volume production (200,000,000 units per year).

The resulting biopolar plates must be able to maintain operating performance for over 5,000 hours and meet the DOE cost target of $5 per kW when projected to high volume production.

The Phase I project should demonstrate of the feasibility of producing a corrosion-resistant bipolar plate that meets the aforementioned technical targets. Phase II deliverables should include a detailed description of the process, a cost analysis for the high volume production of the product demonstrated in Phase I, and an identification of capital equipment specifications and cost.

Questions - contact Peter Devlin (Peter.devlin@hq.doe.gov)

Subtopic a References:

1 "Hydrogen, Fuel Cells, and Infrastructure Technologies Program**,** Multi-Year Research, Development and Demonstration Plan: Planned Program Activities for 2004-2015", describes the planned research, development, and demonstration activities for hydrogen and fuel cell technologies through 2015. (Full text available at: http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/production.pdf)

2 The "H2A" central hydrogen production and small-scale (forecourt) hydrogen production spreadsheets are available for downloading. These spreadsheets contain a title, description, process flow sheet, and stream summary tabs to record useful and descriptive information about the hydrogen production technology in a consistent manner. The performance input, financial inputs, cost input, and replacement capital tabs contain the inputs that drive the calculated results. These models automatically do a rigorous discounted cash flow analysis over the analysis time period based on the specified economic assumptions to calculate the cost of hydrogen produced over the analysis time with the after tax internal rate of return on capital investment. For additional information or to register to use the model go to the H2A website. (URL: http://www.hydrogen.energy.gov/h2a_analysis.html)

3 Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply, April 2005, U.S. Department of Energy, U.S. Department of Agriculture. (URL: http://www.eere.energy.gov/biomass/publications.html)

4 "Hydrogen From Renewable Energy Sources: Pathway to 10 Quads For Transportation Uses in 2030 to 2050", Directed Technologies, October 2003. (Full text available at: http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/iia11_myers.pdf)

5 Municipal Solid Waste in the United States: 2005 Facts and Figures, Executive Summary, U.S. EPA, October 2006 (URL: http://www.epa.gov/msw/msw99.htm)

6 "DOE H2A Analysis", Hydrogen Program, Department of Energy Website. (URL: http://www.hydrogen.energy.gov/h2a_analysis.html)

Subtopic b References:

1 Sivasubramanian, P, et al, "Electrochemical Hydrogen Production from Thermochemical Cycles Using a Proton Exchange Membrane Electrolyzer," *International Journal of Hydrogen Energy*, 32(12): 463-468, March 2007. (Available at: http://www.che.sc.edu/faculty/weidner/Publications/Weidner_IJHE_In_Press.pdf)

2 Lu, P.W., Ammon, R.L., "An Investigation of Electrode Materials for the Anodic Oxidation of Sulfur Dioxide in Concentrated Sulfuric Acid," *Journal of the Electrochemical Society*, 127(12):2610–6, 1980. (Abstract and ordering information available at: http://www.ecsdl.org/dbt/dbt.jsp?KEY=JESOAN)

3 Summers, W. A., "Hybrid Sulfur Thermochemical Process Development," U.S. DOE Hydrogen Program, 2006 Annual Merit Review Proceedings, Hydrogen Production and Delivery. (Presentation available at: http://www.hydrogen.energy.gov/pdfs/review06/pdp_25_summers.pdf)

4 Gorensek, M., Summers, W. and WeidnerJ., "Hybrid Sulfur Cycle Flowsheets for Hydrogen Production from Nuclear Energy", AIChE 2006 Spring Meeting, Orlando, FL, April 26, 2006. (Presentation available at: http://www.aiche-ned.org/conferences/aiche2006spring/session_182/AICHE2006spring-182g-Gorensek.pdf)

Subtopic c References:

1 Hydrogen, Fuel Cells & Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan (Full text available at: http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/fuel_cells.pdf)

Subtopic d References:

1 Borglun, B., "Development of Solid Oxide Fuel Cells at Versa Power Systems", Presented at 2006 Fuel Cell Seminar, Honolulu, HA, November 14, 2006. (Summary available at: http://www.fuelcellseminar.com)

2 Borglun, B., "Cell Technology, Cost Reduction and Quality Management", Presented at The 2nd Real-SOFC Workshop, Simmerath-Einrihr, Germany. June 22, 2005. (URL: http://www.real-sofc.org/events)

3 DOE/NETL Solicitation DE-PS26-00NT40854, Solid State Energy Conversion Alliance (SECA), November 3, 2000. (Full text available at: http://www.netl.doe.gov/business/solicitations/2000pdf/40854/40854_a2.pdf)

4 "Fuel Cell Hangbook", Seventh Edition, by EG&G Technical Services, Inc., Under Contract No. DE-AM26-99FT40575. (Full text available at: http://www.netl.doe.gov/technologies/coalpower/fuelcells/seca/pubs/FCHandbook7.pdf)

23. PETROLEUM INDUSTRY TECHNOLOGIES

In the U.S. petroleum industry, the most energy intensive of all industries, there are approximately 190 small refineries – i.e., those processing 300,000 Bbl/d or less of crude oil. Small refineries are much less efficient than the large refineries, because of the cost of energy-saving technologies and, in some cases, the lack of applicable technologies for smaller operations. Nonetheless, small refinery operations are critical to meeting the Nation's liquid fuel supply, because they make many fuel formulations that are unique to a particular region. For these refineries, most of the energy used by a refinery to process the crude oil to fuel comes from the high-priced crude oil itself. The high cost of energy causes high operating costs, which reduces profitability (and viability). Combined with reduced energy efficiencies, the high operating costs have contributed to the elimination of many small privately-held operations in the US.

This topic seeks the development of technologies to benefit the small refiner, leading to more profitable and efficient operations. Small businesses responding to this topic are encouraged to work directly with a small or independent refiner, or a company that supplies these refiners.

Grant applications are sought only in the following subtopics.

a. Cracking Residual Distillate and Vacuum Gas Oil (VGO)—The extraordinary cost of cracking technology, most notably fluidized catalytic cracking, is quite prohibitive to many smaller refinery operations. Although alternative approaches (such as cracking with the use of concentrated liquid acid) are known, they are difficult to implement and waste disposal is a problem. Grant applications are sought to develop new technology for cracking residual distillate and VGO for potential use by small refineries. Proposed approaches must provide the promise of cost effectiveness for a refiner with limited capital.

Questions – contact Brian Valentine (Brian.Valentine@ee.doe.gov)

b. Hydrogen—Hydrogen is used by petroleum refineries to reduce sulfur, nitrogen, and metallic compounds to the elements and the paraffin residues the elements were part of; hydrogen is also used to facilitate the cracking of heavy distillate residues to lighter hydrocarbon mixtures, and, depending on the hydrocarbon composition of the feedstock mixture, hydrogen is also used for the isomerization reactions of lower octane blending mixtures to higher octane hydrocarbon blends .. Hydrogen use continues to increase, mostly due to lower sulfur diesel fuel requirements. Hydrogen use also has increased in catalytic hydrocracking methods (for residual and VGO fraction treatment in the production of higher value products) and additional hydrogen is needed to meet the continuously increasing demand for reformulated fuels. The reforming of heavy naphtha fraction cannot provide enough hydrogen to meet all refinery needs; therefore, reliable and easily implemented methods for hydrogen manufacture are required. Grant applications are sought to develop new and innovative hydrogen production technologies from any source available to the refiner, in order to help the small refiner meet demands for hydrogen without having to purchase hydrogen over the fence. Proposed approaches must: (1) use materials available to the refiner, although not commonly used to date (e.g., coke and residues); and (2) demonstrate an ability to be implemented in a small refinery at reasonable cost.

Questions – contact Brian Valentine (Brian.Valentine@ee.doe.gov)

c. Heat Integration—Large refineries continue to increase energy efficiency in their operations by the use of heat integration, especially for distillation units (for both inter- and extra-distillation operations). However, not all technology available to a large operation is easily (or meaningfully) adapted in small operations. Therefore, grant applications are sought to develop Innovative heat integration technologies that are especially designed for retrofit in small refinery operations, in order to meet the opportunity of incompletely used waste heat.

Questions – contact Brian Valentine (Brian.Valentine@ee.doe.gov)

d. Optimization—New optimization technology could greatly benefit small refineries. However, techniques for complete refinery optimization and techniques to derive optimum control schemes from optimization analyses are not available. Grant applications are sought to develop linear programming and other optimization technology for refinery operations, accounting for process control integration, fuel blending, and projection of petroleum product market opportunities. Grant applications must address the commercialization of any proposed technology.

Questions – contact Brian Valentine (Brian.Valentine@ee.doe.gov)

References:

1 Meyers, R.A., Handbook of Petroleum Refining Processes, 3rd ed., New York: McGraw-Hill, Inc., 2004. Parts 3, 4, 6, 7, 8, 9, 14 (ISBN-10: 0070417962) (ISBN-13: 978-0070417960)

2 Gary, J. H., Handwerk, G .E., and Kaiser, M. J., Petroleum Refining: Technology and Economics, 5th ed., New York: Taylor & Francis CRC Press, Chapters 6, 8, 10, 12, 13, 18 (ISBN-10: 0824704827) (ISBN-13: 978-0824704827)

3 Maples, R. M., Petroleum Refining Process Economics, 2nd ed., Tulsa: PennWell Corporation, 2000. Sections A, B, C (ISBN-10: 0878147799) (ISBN-13: 978-0878147793)

4 Parkash, S., Refining Processes Handbook, New York: Elsevier 2003. Chapters 2, 3, 4, 5, 6, 8, 11, 13, 14 (ISBN-10: 075067721X) (ISBN-13: 978-0750677219)

5 "Chaper 4: Petroleum Refining", eia: Energy Finance, Website. (URL: http://www.eia.doe.gov/emeu/finance/usi&to/downstream/ch4.html)

6 "Topics for Petroleum Refining and Processing", Energy Information Administration Website. (URL: http://tonto.eia.doe.gov/dnav/pet/pet_pnp_top.asp)

24. SOLAR ENERGY

In 2006 the U.S. Department of Energy began a new Solar America Initiative (SAI) to accelerate the development of advanced photovoltaic systems with the goal of making photovoltaics (PV) cost competitive with other forms of renewable electricity by 2015. In this topic, small businesses are invited to contribute to SAI by "filling technology holes" in the vast array of SAI manufacturing, systems, and projects. Innovative complementary technologies can bolster the likelihood of SAI success by supporting the cost reductions needed in photovoltaic manufacturing and system energy production.

Grant applications are sought only in the following subtopics.

a. Module and System Reliability, and Performance Testing—The current rapid growth in the PV industry has led to diverse and innovative product designs, which frequently require non-traditional tests of reliability and performance. Examples of these non-traditional tests include performance testing and tracking requirements for concentrating PV modules, and software-based system diagnostic tools. Grant applications are sought for innovative methods to monitor PV system and component performance, in order to identify failure and loss mechanisms and to minimize system down time. Approaches of interest include the development of diagnostic tools that are process-oriented and internal to the system components, or those that can be integrated (i.e., "piggy-backed") through ancillary application.

Questions – contact Alec Bulawka (alec.bulawka@ee.doe.gov)

b. Chemical Processing Equipment for Cells and Wafers—Material utilization and waste reduction are primary concerns during wet chemical processes, such as wet etching or chemical surface deposition, used in manufacturing solar cells and wafers. Because many of these processes are similar across varying PV

technologies, improvements to these techniques may have a high payoff across the industry. Therefore, grant applications are sought to develop: (1) enhanced hardware and process-oriented materials conservation methodology for use during manufacture and/or (2) techniques to re-incorporate, where possible, salvageable material during the production process.

Questions – contact Alec Bulawka (alec.bulawka@ee.doe.gov)

c. Material Solutions for Cells and Modules—Further cost reductions at the cell and module level require optimization and automation of all processing steps. Grant applications are sought to develop innovative and cost-effective solutions for assembly-line cell/module integration. Areas of interest include the development of advanced grid contact techniques, improved encapsulation materials, process-enhancement integrable hardware, or other techniques for material-savings oriented.

Questions – contact Alec Bulawka (alec.bulawka@ee.doe.gov)

d. PV Integrated Products—SAI funding currently focuses on reducing the cost of PV-generated electricity across traditional residential, commercial, and utility markets. However, numerous specialty markets exist where the distributed nature of PV allows for cost-effective integration of PV into products. Examples include cogeneration products that produce electricity as well as thermal heat or lighting, or non-grid-tied public infrastructure. Grant applications are sought to develop multiple-use PV solutions such as: (1) effective and efficient electricity/heat co-generation schemes, (2) collection and utilization of waste heat (for example, from PV concentrating systems), and (3) and electronic conversion to supplemental electricity (e.g., the thermoelectric effect).

Questions – contact Alec Bulawka (alec.bulawka@ee.doe.gov)

Subtopic a. References:

1 Quintana, M.A., et al, "Commonly Observed Degradation in Field-Aged Photovoltaic Modules" PV Specialists Conf., 2002 Conf. Record, Twenty-Ninth IEEE, 19-24 May 2002, pp. 1436-1439. (Full text available at: http://www.sandia.gov/pv/docs/PDF/Symposium2003/King.pdf)

2 Ji, L. and McConnell, R., New Qualification Test Procedures for Concentrator Photovoltaic Modules and Assemblies, Proceedings of the IEEE 4th World Conference on Photovoltaic Energy Conversion. Hawaii (2006), pg.721. (ISBN: 1-4244-0017-1)

Subtopic b. References:

1 Proceedings of the 17th Workshop on Crystalline Silicon Solar Cells and Modules: Materials & Processes Vail, Colorado; August 5-8, 2007 (URL: www.nrel.gov/ncpv/)

2 Ratakonda, D., et al, "Rapid Thermal Processing of Screen Printed Ohmic Contacts" J. Electrochem. Soc. Vol 144, Issue 9, pp. 3237-3242, Sep. 1997. (Abstract Available at: http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=JESOAN000144000009003237000001&idtype=cvips&gifs=yes)

Subtopic c. References:

1 Zweibel, K., "The Terrawatt Challenge for Thin-Film PV", NREL Report NREL/TP-520-38350, August 2005. (URL: www.nrel.gov/ncpv/)

2 Rivkin, T., et al, "Direct Write Processing for PV Cells" NREL, Golden, CO. PV Specialists Conf., 2002, Twenty-Ninth IEEE, 19-24 May 2002, pp. 1326-1329. (Abstract available at: http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?tp=&arnumber=1190854&isnumber=26685)

3 Keshner, M.S., and Arya, R., "Study of Potential Cost Reductions Resulting from Super-Large Scale Manufacturing of PV Modules", NREL/SR-520-36846, October 2004 (Full text available at: http://www.osti.gov/bridge/product.biblio.jsp?osti_id=15009939)

Subtopic d. References:

1 Fraas, L.M., et al, "Electricity from Concentrated Solar IR (infra-red) in Solar Lighting Applications", Issaquah, WA; PV Specialists Conf.. Conf. Record of the Twenty-Ninth IEEE; 19-24 May 2002, pp. 963-966. (Abstract available at: http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/8468/26685/01190758.pdf)

2 Black, R.E. Baldasaro, P.F. Charache, G.W. 18th International Conference on Thermoelectrics; 1999, pp. 639-664. (ISBN-10: 0-7803-54516) (ISBN-13: 9-7807-80354-517)

25. VEHICLE TECHNOLOGIES

Hybrid electric vehicles (HEVs) and plug-in hybrids (PHEVs) require further advances in the areas of automotive materials, power electronics, and electric machines to effectively meet anticipated benefits of reduced energy consumption and lower greenhouse gas (GHG) emissions. These technology areas represent some of the most critical barriers to the development and marketing of cost-competitive HEVs and PHEVs. Of particular interest are:

- Lightweight automotive structures and power-train-related material advancements. Lighter automotive structures promise higher vehicle fuel economy through reducing road load and engine power requirements. Power-train materials may enable technologies such as high temperature power electronics, higher efficiency engines, and lower vehicle emissions in light duty automotive or truck applications.

- Advances in materials and designs for advanced electric motors, power electronics, and packaging. These concepts, which include improved electrically insulating substrate materials and increased-power-density, non-permanent magnet motors, can significantly improve the performance, reliability, and economics of efficient energy use in transportation.

Grant applications must show how the proposed innovations would result in significant advances in performance and/or cost reduction over state-of-the-art technologies.

Grant applications are sought only in the following subtopics.

a. Lightweight Automotive Materials—Reducing vehicle weight is one of the most effective means of improving automotive fuel economy. While, all automobile manufacturers are sensitive to this fact, their choice of engineering materials are constrained by many factors, including cost, formability, join ability,

crashworthiness, recyclability, strength-stiffness tradeoffs, and other considerations. Although great strides have been made in recent years in the development of high strength steels, composites, aluminum, and magnesium, many novel material systems have shown the potential of providing designers with highly tailorable properties, including high strength, high stiffness, and low density. These material systems include metal foams, honeycomb structures, novel hybrid sandwich structures, and innovative metal and polymer composites. These materials and structures can be used to reduce weight, consolidate parts, and improve functionality in engine components, wheels, closures, and accessory components. Therefore, grant applications are sought to utilize innovative materials and combinations of materials to develop engineered materials systems that provide significant weight savings for automotive structures. As with the more traditional materials, proposed approaches must take into account considerations of cost, joining, crashworthiness, safety, recyclability, and formability for these novel materials systems.

Questions – contact Rogelio Sullivan (Rogelio.Sullivan@hq.doe.gov)

b. Materials for High Efficiency Transportations Systems—The efficiency and performance of advanced heavy- and light-duty vehicle systems could be improved by the development and implementation of new materials. Therefore, grant applications are sought to develop robust, low cost materials and fabrication techniques for: (1) high temperature (up to 150C) power electronics, high performance power capacitors, and advanced hybrid-electric drive controllers; (2) advanced high efficiency internal combustion engines, in order to address the challenges of new combustion regimes and emissions requirements; (3) advanced high performance sensors for onboard diagnostics, for measurement of exhaust emissions such as NOx or Sox; and (4) improved fuel injection systems with ultra-fine spray tips (holes less than 75 microns), to provide finer control of combustion and improved engine efficiency of advanced heavy and light duty engines. Grant applications also are sought for advanced computational methods that can be used to develop application-specific tailored materials for both internal combustion engines and advanced hybrid/electric drive vehicles – such materials-by-design approaches could address issues in emission control devices, batteries, power electronics, and waste heat recovery systems.

Questions - contact Jerry Gibbs (Jerry.Gibbs@ee.doe.gov)

c. Improved Electrically Insulating Substrate Materials—Electrically insulating substrate materials, utilized in direct-bonded copper substrates (DBCs), represent a significant cost of the high power electronics (such as inverters and DC/DC converters) used in hybrid, plug-in hybrid, and fuel cell vehicles. These materials will be subjected to multiple temperature excursions for prolonged periods; therefore, they must be rugged and resist cracking. In addition, the overall DBC structure must be tailored to match the coefficient of thermal expansion (CTE) of the silicon used in these power electronics devices. That is, the substrate material must be effective in transferring heat from the silicon dies to the heat exchanger, which typically is located under the DBC. Grant applications are sought to develop new electrically insulating substrate materials, and/or to modify existing substrate materials, in order to enhance performance while minimizing costs. Alternative substrates should combine the good mechanical reliability of Si_3N_4 and the high thermal conductivity of AlN, at a cost below that of alumina.

Questions - contact Steven Boyd (steven.boyd@ee.doe.gov)

d. High-Power-Density, Non-Permanent-Magnet, Electric Motor Development for Hybrid, Plug-in Hybrid, and Fuel Cell Vehicles—Although permanent magnet (PM) motors are the preferred choice for advanced vehicle applications, due to their high power density and efficiency, they suffer from a number of limitations: (1) they are costly, due in part to the high price of rare earth magnet materials; and (2) they are speed limited, which prevents the power density from being increased by increasing the operating speed. Both

surface mount and interior PM designs are speed limited: at high speeds, surface PM machines require banding to retain the magnets and interior PM machines require structural bridges to keep the magnets contained. To address these limitations, grant applications are sought to develop new electric motor designs that eliminate the use of permanent magnets. Alternative designs without rare earth magnets may afford fewer limitations on their maximum speeds, thereby realizing higher power densities and lower costs. Attention also should be given to methods for lowering the cost of the drive control and cooling requirements. A system approach should be employed in the design.

Proposed non-PM motors must be compatible with the DOE 2020 FreedomCAR specifications shown in Table 1 below. In addition, designs should be scalable to 120 kW peak power for 18 seconds and a 65 kW continuous power rating. Designs that achieve the motor specifications but transfer cost and volume from the motor to the power electronics are not of interest and will be declined.

Table 1. Motor Specifications

Requirement	**Target**
Peak power output at 20% of maximum speed for 18 seconds and nominal voltage (kW)	55
Continuous power output at 20 to 100% of maximum speed and nominal voltage (kW)	30
Weight (kg)	≤35
Volume (l)	≤9.7
Unit cost in quantities of 100,000 ($)	≤275
Operating voltage (Vdc)	200 to 450; nominal 325
Maximum per phase current at motor (Arms)	400
Efficiency at 10 to 100% of maximum speed for 20% of rated torque (%)	> 95
Torque pulsations-not to exceed at any speed, percent of peak torque (%)	< 5
Ambient (outside housing) operating temperature (ºC)	-40 to +140
Coolant inlet temperature (ºC)	105
Maximum coolant flow rate (liters/min)	10
Maximum coolant pressure drop (psi)	2
Maximum coolant inlet pressure (psi)	20
Minimum isolation impedance-phase terminals to ground (Mohm)	1

Questions - contact Steven Boyd (steven.boyd@ee.doe.gov)

Subtopic a References:

1 Davies, G., Materials for Automobile Bodies, Butterworth-Heineman, Oxford, UK and Burlington, MA, USA, 2003. (ISBN 0-7506-56921)

2 Automotive Lightweighting Materials Annual Progress Report, High Strength Weight Reduction Materials Annual Progress Report. (Full text available at: http://www1.eere.energy.gov/vehiclesandfuels/pdfs/alm_05/cover_contents.pdf)

Subtopic b References:

1 "21st Century Truck Partnership, Roadmap and Technical White Papers"; December 2006, Report No. 21 CTP-003. (Full text available at: http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/21ctp_roadmap_2007.pdf This paper shows the major technological barriers to achieving high efficiency engines for heavy duty applications.)

Subtopic c References:

1 *21st Century Truck Partnership, Roadmap and Technical White Papers*, December 2006, Report No. 21 CTP-003. (Full text available at: http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/21ctp_roadmap_2007.pdf This paper shows the major technological barriers to achieving high efficiency engines for heavy duty applications.)

2 Harper, C. A., Electronic Packaging and Interconnection Handbook, 3rd Edition, (ISBN 0-0713-47453)

3 Licari, J.J. and Enlow, L.R., Hybrid Microcircuit Technology Handbook, Materials, Processes, Design, Testing and Production, 2nd Edition, Noyes Publications, (ISBN 0-8155-14239)

4 Schulz-Harder, J., "Advanced DBC Substrates fro High Power and High Voltage Electronics", Curamik Electronics, paper given at 22nd IEEE Semi Therm Symposium (http://ieeexplore.ieee.org/iel5/10819/34115/01625233.pdf?isnumber=34115&arnumber=1625233)

5 IXYS Corporation Technical Datasheet, (URL: http://scholar.lib.vt.edu/theses/available/etd-04082001-204805/unrestricted/Appendix-A.PDF)

Subtopic d References:

1 Otaduy, P. J., et al., *The Role of Reluctance in PM Motors*, Oak Ridge National Laboratory, June 2005. (Report No. ORNL/TM-2005-86) (Full text available at: http://www.ornl.gov/~webworks/cppr/y2001/rpt/123193.pdf)

2 "Design of PM-Assisted Synchronous Reluctance Motors, Design Analysis, and Control of Interior PM Synchronous Machines," IEEE Industry Applications Society Tutorial Course Notes, October 4, 2004.

3 Hsu, J. S., et al., *Report on Toyota/Prius Motor Design and Manufacturing Assessment*, Oak Ridge National Laboratory, July 2004. (Report No. ORNL/TM-2004-137) (Full text available at: http://www.ornl.gov/~webworks/cppr/y2001/rpt/120761.pdf)

4 Lawler, J. S., et al., *Minimum Current Magnitude Control of Surface PM Synchronous Machines During Constant Power Operation*, IEEE Power Electronics Letters, 3(2), June 2005. (ISSN 1540-7985)

5 Hendershot, J. R., Jr., and Miller, T. J. Design of Brushless Permanent Magnet Motors, Chapter 16, Oxford: Magna Physics Publishing and Clarendon Press, 1994. This chapter contains a good discussion of eddy current and hysteresis core losses. (ISBN: 1-8818-55031)

6 Russell, R. L., and Norsworthy, K. H., *Eddy Currents and Wall Losses in Screened Rotor Induction Motors*, Paper No. 2525U, The Institution of Electrical Engineers, April 1958. This paper shows how eddy currents are generated by a varying magnetic field in a conducting surface using Maxwell's equations. (ISSN: 0018-9510)

7 Slemon, G. R. and Xian, L., *Core Losses in Permanent Magnet Motors*, IEEE Transactions on Magnets, 26: 1653-1655, September 1990. A classic early paper on calculation of core losses. (ISSN: 0018-9464)

8 Mi, C., et al., *Modeling of Iron Losses of Permanent-Magnet Synchronous Motors*, IEEE Transactions on Industry Applications, 39(3), May/June 2003. The latest paper on core loss used during design of the 6 kW fractional slot PM motor with concentrated windings built at the University of Wisconsin, Madison in 2005. (ISSN: 0093-9994)

26. PRODUCTION OF BIOFUELS FROM BIOMASS

The President, in his State of the Union addresses (January 2006 and January 2007), outlined his Advanced Biofuels Initiatives, which seek to break our national dependence on imported oil by accelerating the development of domestic, renewable alternatives to petroleum-based transportation fuels. The Initiatives seek to develop cost competitive cellulosic biofuels as transportation fuels by 2012, and to reduce gasoline usage in the US by 20 per cent in the next ten years (by 2017**).** In order to reach these targets, the Office of the Biomass Program has set an internal R&D goal of reaching an ethanol cost of $1.07 (based on 2002 dollars) per gallon from cellulosic feedstocks (agricultural residues such as stalks and straws, forest-based resources, and dedicated energy crops such as switchgrass and hybrid poplars) by 2012.

One important component of this program is to ensure that cost competitive feedstocks for biofuels production are widely and sustainably available in sufficient quantities and at reasonable costs. The Departments of Energy and Agriculture jointly released a "Billion Ton Study" in April 2005 that determined that the United States has the potential to sustainably generate about 1.3 billion dry tons of various biomass feedstocks annually. These potential resources are available primarily as agriculture and forest derived feedstocks, and are enough to produce the biofuels needed to displace 30 percent of our current gasoline consumption. These feedstocks must be cost-effectively supplied to biorefineries for conversion to biofuels and bioproducts. Biorefineries are processing facilities that extract carbohydrates, oils, lignin, and other materials from biomass, and convert them into multiple products (such as transportation fuels, power, and chemical products) through both biochemical and thermochemical conversion pathways. The Office of Biomass Program is interested in developing new technology to support both of these pathways:

- Biochemical conversion pathways utilize the cellulose and hemicellulose fractions of biomass to produce ethanol. Pretreatment processes such as enzymatic hydrolysis are used to breakdown these fractions to glucose and fermentable 5 and 6-carbon sugars to make ethanol. However, the current cost of cellulosic ethanol production is too high to compete in the market. Therefore, new and improved technologies are needed to make cellulosic biomass-based fuel production more competitive.

- Thermochemical conversion pathways involve the conversion (e.g. by gasification, pyrolysis) of biochemical biorefinery residues, forest residues, agricultural residues, and future energy crops into clean synthesis gas and bio-oil intermediates, which, in turn, are used to produce cost-competitive commodity fuels (such as ethanol) as well as other bioproducts.

Grant applications are sought only in the following subtopics:

a. Handling and Preprocessing of Biomass—Although the joint USDA and DOE study identified a potential resource of 1.3 billion dry tons, the resource is widely distributed, and a number of challenges must be addressed before this resource to can be converted to fuels and products. These challenges include the collection, densification, and transportation of a low density, variable moisture, material with an uncertain composition. The economics are compounded when a single processing plant uses a dedicated feedstock supply, especially where the herbaceous feedstocks are seasonal.

In other commodity industries, this feedstock challenge was resolved through the collection, blending, and agglomeration of multiple resources into a consistent product with a high density, assured quality, and physical characteristics that could hold-up to transportation. For cellulosic biomass, the production of pellets or agglomerates to increase the bulk density of the product to 30–40 pounds per cubic foot will requires a number of process steps, including grinding, blending, and adding a binder for material stability. Although these additional steps add cost and complexity, the operation would be highly desirable if a portable system could be used at farms or in fields to supply a depot, or a distributed pyrolysis or gasification system, that could not otherwise support a large material handling system for a variety of feedstocks.

Grant applications are sought to overcome these technical barriers and develop a palletized system for the production of high-quality, low-cost densified biomass materials. Approaches of interest must: (1) be able to blend woody and agricultural residues, municipal solid waste (MSW), and perennial energy crops, such as switchgrass; (2) improve, through this blending operation, the quality and material handling ability of the material; and (3) minimize capital costs of the system and the quantity of energy used to process the pellets.

Questions - contact Sam Tagore (Sam.tagore@ee.doe.gov)

b. Biomass Gasification/Small-Scale Fuels Synthesis—Gasification converts biomass resources to a synthesis gas that would first be cleaned and conditioned, and subsequently converted to liquid transportation fuels. Gasification is a robust technology that can effectively convert a wide range of biomass resources to fuels. However, current technologies for converting syngas to liquid fuels typically require very large facilities to be economically competitive. For example, the production of Fischer-Tropsch liquids is economically attractive only at scales that are many times larger than envisioned for biorefineries. Similarly, the production of ethanol or other products from syngas also depends on economies of scale to be cost-effective. Therefore, grant applications are sought to convert syngas to fungible liquid transportation fuels cost-effectively at relatively small facilities that process approximately 200 to 500 tons of dry biomass per day. Approaches of interest include the use of existing catalysts in new and innovative reaction geometries, the development of new processing methods, or innovative techniques for using producer gas or other lower-quality gas intermediates to reduce costs. Proposed projects should: (1) focus on production of transportation fuels from gases produced via biomass gasification; (2) assure that the fuels produced will be fungible with existing transportation fuels; and (3) determine the technical and economic feasibility of fuels synthesis from biomass gasification at small scale. Proposed projects may include the operation of existing systems to demonstrate the feasibility of new concepts; however, projects that involve the construction of gasifiers or gas cleaning systems are not of interest and will be declined.

Questions - contact Sam Tagore (Sam.tagore@ee.doe.gov)

c. Biomass Separation Process Technologies—Process streams resulting from the primary fractionation/saccharification of lignocellulosic biomass are typically highly complex slurries that are difficult to process and separate. Such slurries often contain substantial levels of insoluble lignocellulosic solids (10-20% w/w), high concentrations of soluble biomass sugars (greater than 10-20%), and a variety of other soluble components (organic and inorganic acids, aldehydes, phenolics, etc) that are typically present at lower levels.

Advanced separation process technologies are needed for bulk or primary solid/liquid (S/L) separations, as well as for secondary/polishing S/L separations. The new separation technologies would enable more cost effective S/L separations of such slurries, reduce the need for bio/catalysts to tolerate impurities and interfering components, and help reduce the cost of producing fuels and chemicals from biomass processing streams. Grant applications are sought to develop: (1) improved upstream fractionation, to recover products and/or facilitate bio/catalysis, and to reduce the cost of downstream recovery and purification; (2) 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; (3) techniques to remove smaller suspended particles or high molecular weight compounds from partially clarified liquors, in advance of further purification by chromatography or concentration, and/or purification by evaporation and/or crystallization; and (4) efficient membrane separation systems that enable more economic and efficient separation and recovery of specific components (e.g., specific sugars or organic acids) or classes of components (e.g., mixed sugars or mixed phenolics) from clarified biomass hydrolyzate liquors.

Questions - contact Sam Tagore (Sam.tagore@ee.doe.gov)

d. Algae for Biodiesel—Microalgae are unicellular, photosynthetic microorganisms that are abundant in fresh water, brackish water, and marine environments everywhere on earth. These microscopic plants are capable of utilizing CO_2 and sunlight to generate the complex biomolecules necessary for their survival. A class of biomolecules synthesized by many species is the neutral lipids, or triacylglycerols (TAGs). Some microalgae can produce more than 60% of their dry cell weight in the form of lipids under certain conditions. The transesterification of TAGs to form methyl or ethyl esters generates a fuel known as "biodiesel," which can substitute for diesel fuel in unmodified compression-ignition engines. However, conventional sources of TAGs for biodiesel manufacture are not sufficient to meet a significant fraction of the diesel market, which represents one-third of U.S. transportation fuels. Therefore, microalgae represent a promising new source of oil feedstocks for fuel manufacture – algal productivities can be fifty times that of oilseed crops on a per hectare basis.

While recent events in world energy markets have rejuvenated interest in the development and funding of biofuels, the microalgal production of diesel fuel substitutes will require overcoming technical challenges at every stage of the process:

- In the algal cultivation stage, the two main categories of challenges involve the design of the photobioreactor/pond system and the selection/design of the microalgal species. With respect to system design, the technical challenges include: (1) analyzing capital and operating costs, (2) maintaining temperature control, (3) assessing water requirements (source, recycle, chemistries and evaporation issues), (4) determining CO_2 availability and delivery methods, (5) assessing power plant flue gas compatibility and $CO_2/SO_x/NO_x$ remediation, (6) providing necessary microalgal nutrients, and (7) examining the environmental impacts. Selecting the right starting microalgal species for high-level oil production would involve screening microalgal collections and species from nature for the best productivity characteristics (including growth rate, oil content and fatty acid profile, robustness, resistance to invasion, and biofouling propensity), or metabolically engineering microalgal strains for enhanced lipid productivity (by mutation and selection/screening, or by directed/rational approaches). A Systems Biology approach may be useful to understand and control lipid biosynthesis, and to potentially eliminate the requirement for nutrient induction.

- In the oil (lipid) recovery stage, the hurdles will include developing methods for de-watering, lipid (oil) extraction, and purification of the neutral lipids, along with addressing the attendant costs, energy input, and environmental issues arising from these practices. After removing the oil, a further challenge will be to extract value from the residual biomass, which should be an important consideration that goes into the design of a cost effective process.

- Lastly, in the fuel production stage, technical challenges include process optimization; determining fatty acid profiles, additives required, and fuel characteristics (energy density, carbon number, cloud point, stability, consistency, etc.); conducting cost and life cycle analyses; and performing engine testing to ensure that ASTM standards are met.

Grant applications are sought to develop innovative technologies for addressing one or more of the above technical challenges, leading to a microalgae aquaculture system for the production of lipids as a feedstock for biodiesel. Proposed approaches must demonstrate cognizance of realistic scenarios of land and water use, and must not compete with agricultural production of food.

Questions - contact Sam Tagore (Sam.tagore@ee.doe.gov)

Suptopic a References:

1. Adapa, P., et al, "Compression of Fractionated Suncured and Dehydrated Alfalfa Chops into Cubes – Specific Energy Models", *Bioresource Technology* 98(2007)38-45. (Full text available at: http://homepage.usask.ca/~pka525/drying/Paper/Journal%20Papers/Cubing%20Papers/Energy%20Models/Cube%20specific%20energy%20models.pdf)

2. Arinze, E.A, et al, "Aerodynamic Separation and Fractional Drying of Alfalfa Leaves and Stems", *Drying Technology* 21(9):1673-1702. 2003. (Full text available at: http://www.informaworld.com/smpp/content~content=a713628507~db=all)

3. Igathinathane, C., et al, "Mass and Moisture Distribution in Above Ground Components of Standing Corn Plant", *Transactions of the ASAE* 49(1):97-106. 2006. (Full text is available at: http://bioprocessing.ag.utk.edu/Publications/1-Articles/TRANS%20ASABE%202006%20Mass%20Moisture%20Distribution-Igathinathane%20et%20al.pdf)

4. Mani, S., et al, "Economics of Producing Fuel Pellets from Biomass", *Applied Engineering in Agriculture* 22(3):421-426. 2006. (Full text is available at: http://asae.frymulti.com/abstract.asp?aid=20447&t=2)

5. Rizzato, E. and Knight, A., "A Study of Techniques for Segregating Previously Disconnected Botanical Fractions of Cereal Straw", *Industrial Crops and Products. An International Journal* 5(1996) 107-118. (ISSN 0926-6690)

6. Sokhansanj, S. and Turhollow, A., "Biomass Densification – Cubing Operations and Costs", *Applied Engineering in Agriculture* 20(4): 495-499. 2004. (Full text available at: http://asae.frymulti.com/abstract.asp?aid=16480&t=2)

Subtopic b References:

1. Spath, P. L. and Dayton, D. C., "Preliminary Screening -- Technical and Economic Assessment of Synthesis Gas to Fuels and Chemicals with Emphasis on the Potential for Biomass-Derived Syngas" Golden, CO, National Renewable Energy Laboratory**:** 160 pp. 2003. (Full text available at: http://www.nrel.gov/docs/fy04osti/34929.pdf)

2. McKendry, P. "Energy Production from Biomass (Part 1): Overview of Biomass." *Bioresource Technology* 83(1): 37-46. 2002. (ISSN 0960-8524)

3. McKendry, P. "Energy Production from Biomass (Part 2): Conversion Technologies." *Bioresource Technology* 83(1): 47-54. 2002. (ISSN 0960-8524)

4. McKendry, P. (2002). "Energy Production from Biomass (Part 3): Gasification Technologies." *Bioresource Technology* 83(1): 55-63. (ISSN 0960-8524)

Subtopic c References:

1. Aden, A., et al., "Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover", National Renewable Energy Laboratory, 2002 Design Report (Abstract available at: http://www.stormingmedia.us/96/9646/A964634.html)

2. "National Laboratory Market and Technical Assessment of the 30x30 Scenario", National Renewable Energy Laboratory. (This is an internal reference, please contact Bob Wallace in NREL via e-mail at robert_wallace@nrel.gov)

Subtopic d References:

1. A Look Back at the U.S. Department of Energy's Aquatics Species Program: Biodiesel from Algae – Close-Out report. (URL: http://govdocs.aquake.org/cgi/content/abstract/2004/915/9150010)

2. Chisti, Y., "Biodiesel from Microalgae", Biotechnology Advances 25:294-306. 2007. (Full text available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T4X-4N20704-1&_user=10&_coverDate=06%2F30%2F2007&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=d406dbce09caa6c8cf313b59230aefbe)

27. OCEAN ENERGY TECHNOLOGY DEVELOPMENT

Ocean hydrokinetic technologies capable of extracting electrical power from wave, tidal, currents, and ocean thermal technologies capable of extracting power from temperature differences between the surface and deep ocean are immature; yet, an emerging domestic and international industry is moving rapidly to develop and deploy demonstration devices at sea. Support for a Federal ocean renewables program has been gaining momentum to address the emerging global market potential. U.S. Department of Energy (DOE) Wind and Hydropower Technology Program (WHTP) under the Office of Energy Efficiency and Renewable Energy (EERE), has begun preliminary planning, in close partnership with industry and the national laboratories, to start a Federal program designed to accelerate the technology evolution of commercial-scale Ocean Energy systems.

Ocean energy systems are typically developed along careful multi-step pathway leading from design concept, to scale model development, laboratory testing, open water testing, full-scale open water testing, and finally to commercial demonstration. Companies are often judged by how far they have proceeded along a gauntlet of regulatory requirements, structural design development; scientific evaluation and testing; and bench-scale, pilot-scale, and full-scale demonstrations. A more valuable metric for evaluating technical viability and commercial applicability would be to grade the technologies upon performance, cost, and reliability criteria that can be effectively applied to each device in a standardized format.

This topic addresses the commercial development path, with Phase 1 designed to demonstrate, through analysis, the viability of concepts on the basis of performance, cost, and reliability. Concepts shall be judged by their potential to achieve and demonstrate competitive life-cycle cost of energy based on rigorous engineering analysis. Applicants are encouraged to submit design plans and accompanying analysis for advancing a design or concept to the next level of development. Eligible Ocean Energy projects would include:

- New concepts designs
- Design/build/test plans to advance a concept to scale model testing
- Design/build/test plans to advance a scale model design to full-scale open water testing
- Design/build/test plans to advance a prototype to full-scale demonstration

Each device configuration is different in terms of its capture mechanism and conversion technology. Emphasis in Phase 1 will be on the applicant's capability to 1) demonstrate the economic potential of the proposed concept, and 2) provide analysis to demonstrate accurate accounting of external conditions and load response for generating engineering design load cases. Economics shall be based on an arbitrary 50-MW utility scale generating plant under external conditions defined by the applicant.

Proposed projects that involve the participation of a DOE national laboratory must obtain approval from the laboratory prior to submission, and provide evidence of that approval in the grant application.

Grant applications are sought only in the following subtopics.

a. Ocean Wave Energy Converters—Wave energy converters have significant potential for utility-scale energy production, but even while dozens of international companies are currently developing systems, only a few commercial scale projects have been deployed worldwide. Grant applications are sought to assist these companies in advancing critical wave energy conversion technologies – including point absorbers, oscillating water column devices, over-topping devices, and wave attenuators – along the commercial development path by demonstrating the economic and technical viability of their inventions.

Grant applications must provide: (1) a technical and integrated operational description of the proposed system; (2) an analysis for determining critical design load cases for the concept; (3) a discussion of the cost viability of the concept at utility scale; and (4) a discussion of the economics, based on expected energy production, initial capital cost, and reliability in terms of maintenance, refurbishment, levelized replacement costs, and decommissioning. The Phase I report should summarize the analysis methods used to determine key performance, cost, and reliability parameters, and to accurately determine external conditions, operating load responses, and design load cases. It also should provide the details of all analyses, including a scaling exercise to expand the concept to a 50-MW project scale.

Note that the focus of this topic is on wave energy conversion systems that can be expanded to 50-MW electric power facilities. Applications dealing with partial systems are not of interest and will be declined.

Questions - contact Dennis Lin (dennis.lin@ee.doe.gov)

b. Hydrokinetic Turbines—Devices that operate on the principal of converting the kinetic energy of moving water currents (including tidal, ocean, or river currents) into electricity have the potential to play a role in utility-scale energy production. Although dozens of international companies are currently developing systems, only a few commercial scale prototypes have been deployed worldwide. Grant applications are sought to assist these companies in advancing critical hydrokinetic turbine technologies – including horizontal and vertical axis

water turbines, either tethered or fixed-mounted in a moving water stream – along the commercial development path by demonstrating the economic and technical viability of their systems.

Grant applications must provide: (1) a technical and integrated operational description of the proposed system; (2) an analysis for determining the critical design load cases of the concept; (3) a discussion of the cost viability of the concept at utility scale; and (4) a discussion of the economics, based on expected energy production, initial capital cost, and reliability in terms of maintenance, refurbishment, levelized replacement costs, and decommissioning. The Phase I report should summarize the analysis methods used to determine key performance, cost and reliability parameters. It also should provide the details of all analyses including a scaling exercise to determine the system economics for the concept at a 10-MW project scale.

Note that the focus of this topic is on hydrokinetic energy conversion systems that can be expanded to 10-MW electric power facilities. Applications dealing with partial systems are not of interest and will be declined.

Questions - contact Dennis Lin (dennis.lin@ee.doe.gov).

c. Ocean Thermal Energy Conversion Systems (OTEC): Systems that generate power using the temperature difference between cold deep water and warm surface water were first proposed in 1881 by d'Arsonval and were demonstrated in Cuba in 1930 by Georges Claude. Despite large public and private investments over the years, a commercial technology has not yet emerged. The challenges of: low thermal efficiencies due to the relatively small temperature differences in the ocean; high capital costs due to the low efficiencies and the ocean environment; geographic constraints due to the need for warm surface and cold deep water and due to the need to get the electric power to shore; and the difficulties of ocean engineering have all limited development. Today, advances in heat exchanger design and materials and in power conversion systems have increased the technical potential; the identification of new end products such as ammonia and, in the longer term, hydrogen have reduced the geographic constraints; and increased costs for products such as ammonia have increased the economic potential. These and other factors make it worthwhile to re-examine the OTEC opportunity.

Areas of interest include OTEC systems. The Phase I report should summarize and detail the analysis methodology and results for the cost, performance, and reliability, production, external conditions, and operating load responses and design load cases. It should provide the details of the analyses including a scaling exercise to expand the concept to a 50-MW project scale (or 100 MW if that is determined to be a more commercially viable scale). Applications dealing with partial systems are not of interest and will be declined.

Grant applications must provide (1) a technical and integrated operational description of the proposed system; (2) a detailed engineering analysis of the concept at full scale; (3) a detailed engineering-economic analysis of the system at full scale based on the system and component capital costs, O&M costs (including refurbishment, levelized replacement, etc.), labor, fuel, and other costs such as decommissioning, and the expected energy and/or other (ammonia, hydrogen, water, etc.) production returns; and (4) analysis of the critical design factors of the approach.

Questions - contact Dennis Lin (dennis.lin@ee.doe.gov)

Subtopic a. References:

1. Hagerman, G. and Bedard, R. "E2I/EPRI Specification – Guidelines for Preliminary Estimation of Power Production by Offshore Wave Energy Conversion Devices" E2I/EPRI-WP-US-001, December 22, 2003.

2. Previsic, M., Siddiqui, O., and Bedard, R. "EPRI Global E2I Guideline: Economic Assessment Methodology for Offshore Wave Power Plants" E2I/EPRI WP-US-002 Rev 4, November 30, 2004.

3. Previsic, M. and Bedard, R. “Methodology for Conceptual Level Design of Offshore Wave Power Plants” E2I/EPRI WP 005-US, June 9, 2004.

Subtopic b. References:

1. Hagerman, G., Polagye, B., Bedard, R., and Previsic, M. “ Methodology for Estimating Tidal Current Energy Resources and Power Production by Tidal In-Stream Energy Conversion (TISEC) Devices” EPRI-TP-001-NA Rev 3, September 29, 2006.

2. Bedard, R. Siddiqui, O. Previsic, M., and Polagye, B., “Economic Assessment Methodology for Tidal In-Straem Power Plants”, EPRI-TP-002 NA Rev 2, June 10, 2006.

3. Previsic, M. and Bedard, R., “Methodology for Conceptual Level Design of tidal In-Stream Energy Conversion (TISEC) Power Plants”, EPRI TP-005 NA, August 26, 2005.

Subtopic c. References:

1. Thomas B. Johansson, Henry Kelly, Amulya K.N. Reddy, and Robert H. Williams, “Renewable Energy: Sources for Fuels and Electricity”, Island Press, 1993

2. Patrick Takahashi and Andrew Trenka, “Ocean Thermal Energy Conversion”, John Wiley & sons, 1996.

*All references can be accessed at: http://archive.epri.com/oceanenergy/streamenergy.html#reports

OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

28. NATURAL DISASTER REDUCTION THROUGH TECHNOLOGY

The U.S. electric power sector is a critical part of our society. Virtually all aspects of residential, industrial, and commercial activities depend on safe, reliable, and affordable electricity. Electricity is among the most infrastructure-intensive segments of the energy sector – the electricity grid includes a network of 5,000 power plants with a generating capacity of 800,000 megawatts, 100,000 high-voltage transformers, 63,000 substations, and 158,000 miles of transmission lines. In some cases, this infrastructure is operating at-or-near capacity. Therefore, the potential to be in a supply-shortfall position when affected by a natural disaster has never been greater.

Any prolonged interruption in the supply of electricity would be devastating to the nation. Natural disasters, including major weather events, have caused damage to the electricity infrastructure, resulting in high energy-loss consequences, as well as subsequent public health, safety, and economic losses. For example, hurricanes Katrina and Rita impacted Florida, Alabama, Mississippi, Louisiana, and Texas, resulting in widespread power outages to residential, commercial, and industrial customers. The long-term power outages caused disruption to all parts of society, including inter-dependent critical infrastructure such as communication, oil refineries, pumping stations, pipelines, and gasoline stations.

Reducing the consequences of such disasters has been accomplished by implementing sound emergency management policies that involve close coordination between federal, state, and private stakeholders.

Nonetheless, there remain many technological approaches which could decrease vulnerability and accelerate recovery of the electric grid. The most urgent research issues include: (1) advanced power electronics for faster routing of electricity flow and for integration of storage and renewables as buffers, (2) simulation models to assist in recovery measures, and (3) the development of restoration software tools based on advanced sensor data to rapidly ascertain the state of the grid.

Grant applications are sought only in the following subtopics.

a. Vulnerability Reduction Via Advanced Power Electronics—High-voltage/high-current power electronics devices allow precise and rapid switching of electric power to support long-distance transmission. Power electronics are essential for integrating devices such as energy storage, photovoltaic arrays, microturbines, and wind power integration with the local electric distribution system. During abnormal grid operation and interruptions, power electronics can be used as grid shock absorbers, current limiters, and to improve power flow management. Advanced power electronic devices could assist in the recovery from brownouts and blackouts, either short or extended. Therefore, grant applications are sought to develop new power electronic devices to aid in minimizing the impact of, and assisting in the recovery from, natural disasters. These devices must be able to withstand harsh and chaotic electrical perturbations such as frequency fluctuations, erroneous loops flows, large voltage sags and swells, and current surges that can be experienced during a natural disaster.

Questions – contact Imre Gyuk (imre.gyuk@hq.doe.gov)

b. Simulation Models—Grant applications are sought to develop simulation models to improve recovery from disruptions of critical electricity infrastructure, or when possible, preclude such a situation from occurring. The aim is to develop tools that could quickly alert operators and recommend corrective control actions that may be taken to alleviate an existing or potential problem in the system, and return the system to a stable state. Some examples include refined "real-time" tools for contingency analysis; modeling interdependencies; analyzing potential overload and/or short-circuit conditions; and estimating restoration time. Projects with an emphasis on the high-voltage transmission system are preferred. Also of interest are simulators that provide a realistic environment for operators to practice procedures under emergency operating situations.

(**Note distinction between subtopics b and c:** the intent of this subtopic is to develop enhanced decision support tools, whereas subtopic c focuses on providing operational understanding of system status through sensor measurements.)

Questions – contact Gil Bindewald (gilbert.bindewald@hq.doe.gov)

c. Restoration Software Based on Advanced Sensors—Sensors are an essential component in the operation and maintenance of energy systems, and advanced sensors could aid in disaster reduction. These sensor networks, located on the transmission and distribution system, would allow control area operators to record the status of the grid prior to a large disturbance and determine line status after a disaster and where generation capacity can be matched with load. Grant applications are sought to develop software tools that use time-synchronized sensor data from all parts of the transmission grid, individually or in combination, to aid operators in restoring full service across a region. The sensor data of interest would be derived from phasor measurement units (PMUs), digital fault recorders with GPS-synchronization, and intelligent electronic devices in substations for time synchronized circuit breaker monitoring. Such sensors could provide information on phase angles to re-synchronize circuits in the system, real and reactive power flows, breaker positions, dynamic line loading conditions, and low-frequency oscillations during the grid restoration process. By operating on these data with appropriate software tools, system operators then could reconfigure electricity flow to restore power to the grid safely and efficiently, while isolating any problem areas.

Questions – contact Phil Overholt (Philip.overholt@hq.doe.gov)

References:

1. National Energy Policy (URL: http://www.whitehouse.gov/infocus/energy/)

2. Department of Homeland Security. (2006). *National Infrastructure Protection Plan*. (Full text available at: http://www.dhs.gov/xlibrary/assets/NIPP_Plan.pdf)

3. Department of Energy (August 2006). *Five Year Program Plan for Fiscal Years 2008 to 2012 for Electric Transmission and Distribution Programs, A Report to the United States Congress Pursuant to Section 925 of the Energy Policy Act of 2005*. (Full text available at: http://www.oe.energy.gov/DocumentsandMedia/Section_925_Final.pdf)

4. Generator Black Start Validation Using Synchronized Phasor Measurements, Koellner, Kris; Anderson, Chris; and Moxley, Roy, Western Protective Relay Conference, October 2005. http://www.selinc.com/techpprs/6208_GeneratorBlack_RM_20070607.pdf

5. Department of Energy (August 2006). *Five Year Program Plan for Fiscal Years 2008 to 2012 for Electric Transmission and Distribution Programs, A Report to the United States Congress Pursuant to Section 925 of the Energy Policy Act of 2005*. (Full text available at: http://www.oe.energy.gov/DocumentsandMedia/Section_925_Final.pdf)

.

29. ADVANCED ENERGY STORAGE AND POWER ELECTRONIC SYSTEMS

As energy storage systems continue to advance, two areas have surfaced in which technology advances are needed:

- In battery or electrochemical capacitor strings, slight differences in individual cells can grow over time, leading to premature failure of the system. External circuitry sometimes is applied in an attempt to minimize this problem. Solutions for intrinsic cell balancing, without the use of external circuitry at the cell level, are sought.

- As silicon carbide devices become more available for system level power electronic applications, wire bonding of these devices into circuits is expected to become a reliability issue. Solutions are sought for novel "wireless" bonding techniques to alleviate this potential problem.

Grant applications are sought only in the following subtopics.

a. Intrinsic Cell Balancing for Advanced Energy Storage Systems—In most energy storage applications, individual electrochemical cells and/or capacitors are connected together in a variety of series/parallel configurations to form modules, strings, and ultimately systems. During repeated charge and discharge of the system, differences in the behavior of individual cells can lead to cell imbalances, which can lead to system failure. In many cases, the systems are externally monitored at the cell level in order to minimize abuse of the cells themselves – abuse that can lead to shortened lifetime or, in the worst case, a potentially life-threatening situation (e.g., overcharge leading to thermal runaway and deflagration). As larger and larger systems are built to meet large-scale utility applications, the potential for these imbalances increases significantly, and the

complexity of the required monitoring circuits and control software leads to increased costs and decreased reliability. In order to obviate the need for this additional circuitry and electronic monitoring/control of individual cells, grant applications are sought to develop new approaches to cell balancing for batteries and electrochemical capacitors. Possible examples include the use of either intrinsic or external techniques such as overcharge redox shuttles in each cell or module-level circuitry and algorithms to replace individual cell-level systems. Designs and approaches that are applicable to multiple battery and capacitor chemistries are preferred.

Questions – Imre Gyuk (imre.gyuk@hq.doe.gov)

b. Advanced Bonding Techniques for Silicon Carbide (SiC) Switches—Wide band-gap devices such as silicon carbide (SiC) are becoming more attractive to various applications – such as high power motor drives, Flexible AC Transmission Systems (FACTS) controllers, and power conversion systems – because of their increase in performance compared to silicon-based systems. Advantages include lower losses, high operating frequencies, higher operating voltages, and higher operating temperatures. Most SiC devices to date utilize one or more wire bonds to provide the electrical path needed for conduction. These wire bonds are typically made of aluminum or gold wires that are ultrasonically or thermosonically bonded to bond pads on the SiC chip. However, such wire bonds are known to have catastrophic failure mechanisms that occur during high current or high temperature cycling. The wire bonds also add to the overall electrical inductance of the switch and can be especially problematic in high frequency power applications. Consequently, these wire bonds often are considered the weakest link in the overall packaging. Grant applications are sought to develop an advanced wire-bondless approach to high power (greater than 100A and 10kV) SiC packaging. The Phase I project should examine the feasibility of a wire-bondless approach along with the current state of research and development. The potential Phase II project would include the testing and improvement of these devices and the inclusion of these devices into power conversion system for high power applications.

Questions – Imre Gyuk (imre.gyuk@hq.doe.gov)

References:

1 Kiessling, R., and J. Mills, "A Battery Model for the Monitoring of, and Corrective Action on, Lead/Acid Electric-Vehicle Batteries", *Journal of Power Sources*, Volume 53, Number 2, February 1995 , pp. 339-340(2). (URL: Elsevier, http://www.ingentaconnect.com/content/els/03787753;jsessionid=awhhevxtagej.henrietta Publisher link: http://www.ingentaconnect.com/content/els;jsessionid=awhhevxtagej.henrietta)

2 Lee, Yuang-Shung, Ming-Wang Cheng, Shun-Ching Yang, and Co-Lin Hsu, "Individual Cell Equalization for Series Connected Lithium-Ion Batteries", *IEICE-Transactions on Communications*, Volume E89-B, Number 9, Pp. 2596-2607 (URL: http://ietcom.oxfordjournals.org/ Another link: http://ietcom.oxfordjournals.org/content/volE89-B/issue9/index.dtl)

3 Baughman, A.; Ferdowsi, M., "Double-Tiered Capacitive Shuttling Method for Balancing Series-Connected Batteries", *Vehicle Power and Propulsion*, 2005 IEEE Conference , no. pp. 109- 113, 7-9 Sept. 2005. (URL: http://scholarsmine.umr.edu/post_prints/01554531_09007dcc8030d80c.html)

4 Bentley, W.F., "Cell Balancing Considerations for Lithium-Ion Battery Systems", *Battery Conference on Applications and Advan*ces, 1997., Twelfth Annual, 14-17 January 1997, pp 223-226. (URL: http://ieeexplore.ieee.org/xpl/RecentCon.jsp?punumber=4373 (another link: http://ieeexplore.ieee.org/Xplore/login.jsp?url=/search/searchresult.jsp?disp=cit&queryText=(bentley%20%20w.%20f.%3cIN%3eau)&valnm=Bentley%2C+W.F.&reqloc%20=others&history=yes)

5 Skarstad, Paul M., "Battery And Capacitor Technology for Uniform Charge Time in Implantable Cardioverter-Defibrillators", *Journal of Power Sources,* Volume 136, Issue 2, 1 October 2004, Pages 263-2. (URL: http://www.sciencedirect.com/science/journal/03787753 another link: http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%235269%232004%2399 8639997%23520265%23FLA%23&_cdi=5269&_pubType=J&view=c&_auth=y&_acct=C000059129&_ve rsion=1&_urlVersion=0&_userid=2914253&md5=b23c1ef1a48a5055452f647290097fcf)

30. HIGH TEMPERATURE SUPERCONDUCTIVITY

Substantial worldwide advances have been achieved in recent years with respect to the development and processing of second generation, high temperature superconducting (HTS) coated conductors (also known as "2G wires"). Highly successful prototype superconducting equipment and devices are being demonstrated. Compared to first generation wires, 2G coated conductors have the potential of providing lower cost and higher performance. These wires also provide the possibility of operation at moderate magnetic fields in liquid nitrogen as well as high fields at lower temperatures. For short laboratory-scale samples, very high current-carrying capacities (over 1,000 A/cm at 77K) have been reported. In addition, pre-commercial coated conductors as long as 600 meters, with current carrying capacity over 170 A/cm, have been demonstrated. Nonetheless, further innovation and development will be needed to achieve the DOE vision for commercial availability of 2G wires that have a cost/performance ratio as low as $10-30/kA-m (dollars per kiloampere-meter) and can be fabricated in practical forms. In addition to wires, further improvements in the efficiency, reliability, and cost reduction of the enabling cryogenic system are needed.

Grant applications are sought only in the following subtopics.

a. AC Loss Reduction in Coated Conductors (ref. 1-4) —Although a number of strategies (filamentization, multi-wire stranding, twisting and transposition) have been shown to reduce AC losses in superconducting wires and cables, all of them have limitations for 2G wires. For example, because 2G wire consists of a continuous layer of HTS, filamentization would require the additional step of physically removing part of the HTS layer. Filamentization difficulties are compounded by the presence of relatively large textured grains, which are contained within certain 2G templates and can range from 30 to 60 microns in size. The presence of these grains may place a lower limit on the width of the HTS filaments; yet, narrow filaments are desirable because they are more effective in reducting AC losses. The twisting and transposition strategy also has drawbacks – the flat tape geometry of present 2G wire does not lend naturally to twisting and transposition, due to mechanical concerns.

Grant applications are sought to develop innovative and cost effective approaches to reduce the AC losses of coated conductors. Approaches of interest include filamentization and substrate modification, including single crystalline round or low-aspect-ratio textured templates.

- With respect to approaches that address the continuous filamentization of the HTS and/or stabilizer, grant applications should develop a potentially cost effective filamentation technique, and determine the influences of such critical parameters as HTS filament shape, arrangement, and geometry on loss characteristics under various operating conditions. Loss characteristics may include properties such as hysteretic, coupling, eddy current, and transport losses, projected over broad ranges of frequencies and field-sweep amplitudes.

- With respect to approaches that address textured substrate fabrication, the substrates either must be single crystalline or must contain well-oriented grains less than five microns in size, with grain misorientation angles less than eight degrees full-width-half-maximum. The substrates also must be

suitable for continuous fabrication and be able to sustain a critical current density of more than one MA/cm^2 at 77K self-field. Also, textured templates that have either round or low aspect ratio cross sections are preferred.

Questions – contact Debbie Haught (debbie.haught@hq.doe.gov)

b. High Performance and Reliable 2G Wire Joints—Although superconducting equipment requires long lengths of 2G wires, practical HTS wires are of finite lengths. Consequently, wire joining is required during device manufacturing, installation, and field repair. To ensure safe and reliable operation, high performance joints must have good mechanical and electrical integrity. Due to the different architectures and manufacturing processes of various commercial 2G wires, characteristics of the joints are expected to vary with joint fabrication conditions as well as with the type of 2G wire being used. Also, the asymmetric nature of present 2G wires likely will influence the joint characteristics depending on the joining arrangement (i.e., whether the joints are fabricated in face-to-face, back-to-back, or face-to-back configurations). At present, only limited information on 2G wire joints is available; further information must be developed in order to ensure reliable 2G wire joints for HTS applications.

Grant applications are sought to develop innovative and cost-effective ways to prepare high quality, reliable, joints for superconducting 2G wires, either to one-another or to non-superconducting wires. Approaches of interest must include a detailed determination of the effects of the joining method on the properties of 2G wires –including joint resistance, ac losses, and stability strength – and on the interdependence between these properties prepared under various conditions. The determination of these effects must account for the fact that the wires may have been prepared under various conditions and may have different wire architectures.

Questions – contact Debbie Haught (debbie.haught@hq.doe.gov)

c. Cryogenic Technology for Superconductors—In order to realize the benefits of superconducting equipment, HTS wires must be maintained at temperatures well below ambient. Potential applications for these superconductors will most likely be realized if the operating temperature can be maintained economically in the range 63-83K. To economically achieve and maintain these temperatures, further development in thermal insulation systems (cryostats) and refrigerators (cryo-coolers) is needed.

Grant applications are sought to develop flexible cryostats (ref. 5-6) that are suitable for HTS electrical cable that might be placed underground or underwater. These cryostats should offer superior performance and lower price compared to today's commercially available products. For comparison, current flexible cryostats are manufactured in 100 m lengths, have a price of approximately $500/m, admit heat at the rate of 1-3 W/m, and suffer increased heat loads at bends in the cable. Also the getters used in the vacuum region of these cryostats have lifetimes significantly shorter than the 20-30 year HTS cable lifetime the utilities expect and improved getters are needed as a getter reconditioning or replacement for a long, underground HTS cable is difficult. Cryostats for future HTS cables must be much longer (kilometers), have a reduced price ($200/m), a reduced rate of heat invasion (e.g., less than 1 W/m), minimize performance degradation at bends and have improved getter lifetimes. Proposed cryostats must have the potential to satisfy most or all of these requirements.

Grant applications also are sought to develop efficient, reliable and cryo-coolers (ref. 7). These cryo-coolers should have the potential for unattended, maintenance-free operation for at least 10 years, and be able to function in an underground ~~and/or underwater~~ environment. Proposed approaches must offer the prospect of future price reductions to less than $50/watt at 65K.

Questions – contact Debbie Haught (debbie.haught@hq.doe.gov)

References:

1 S.P. Ashworth, F. Grilli, "A strategy for the reduction of ac losses in YBCO coated conductors," *Superconductor Science and Technology* 19 (1006) 227-232. (Abstract available at: http://www.iop.org/EJ/abstract/0953-2048/19/2/013).

2 M.D. Sumption, E.W. Collings, and P.N. Barnes, "AC Loss in Striped (Ffilamentary) YBCO Coated Conductors Leading to Designs for High Frequencies and Field-Sweep Amplitudes," *Superconductor Science and Technology* 18 (2005) 122-134. (Abstract available at: http://www.iop.org/EJ/abstract/0953-2048/18/1/020)

3 T. Nishioka, N. Amemiya, N. Enomoto, Z.A. Jiang, Y. Yamada, T. Izumi, Y. Shiohara, T. Saitoh, Y. Iijima, and K. Kakimoto, "AC loss of YBCO Coated Conductors Fabricated by IBAD/PLD Method," *IEEE Trans. On Appl. Supercond*. 15 (2005) 2843-2846. (Abstract available at : http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?tp=&arnumber=1440260&isnumber=31008)

4 R.C. Duckworth, M.J. Gouge, J.W. Lue, C.L.H. Thieme, D.T. Verebelyi, "Substrate and Stabilization Effects on the Transport AC Losses in YBCO Coated Conductors," *IEEE Trans. On Appl. Supercond*. 15 (2005) 1583-1586. (Abstract available at : http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?tp=&arnumber=1439949&isnumber=31007)

5 M. J. Gouge, "Flexible Cryostats for Superconducting Cables: Reliability and Lifetime Issues," DOE 2006 Wire Development Workshop: http://www.energetics.com/meetings/wire06/pdfs/session7/gouge.pdf

6 K. Schippl, "Very Low Loss Cryogenic Envelope for long HTS Cables," http://www.cryo-schippl.de/EUCAS%202003%20-%20Paper.pdf

7 M. J. Gouge, J. A. Demko and B. W. McConnell, ORNL, J. M. Pfotenhauer, University of Wisconsin, "Cryogenic Assessment Report," http://www.ornl.gov/sci/htsc/documents/pdf/CryoAssessRpt.pdf

OFFICE OF FUSION ENERGY SCIENCES

31. ADVANCED TECHNOLOGIES AND MATERIALS FOR FUSION ENERGY SYSTEMS

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

Grant applications are sought only in the following subtopics:

a. Plasma Facing Components—The plasma facing components (PFCs) in energy producing fusion devices will experience 5-15 MW/m^2 surface heat flux under normal operation (steady-state) and off-normal energy deposition up to 1 MJ/m^2 within 0.1 to 1.0 ms. Refractory solid surfaces represent one type of PFC option. These PFCs are envisioned to have a refractory metal heat sink, cooled by helium gas, and a plasma facing

surface, consisting of an engineered refractory metal surface or a thin coating of refractory material that minimizes thermal stresses. The materials being considered include tungsten and molybdenum alloys. Grant applications are sought to develop: (1) innovative refractory alloys having good thermal conductivity (similar to Mo, at a minimum), resistance to recrystallization and grain growth, good mechanical properties (e.g., strength and ductility), and resistance to thermal fatigue; (2) coatings or specialized low-Z surface treatments of refractory alloy armor for improved plasma performance; (3) innovative refractory-metal heat sink designs for enhanced helium gas cooling; (4) efficient fabrication methods for engineered surfaces that mitigate the stresses due to high heat flux; and (5) joining methods, for attaching the plasma facing material to the heat sink, that are reliable, efficient to manufacture, and capable of high heat transfer – these new joining techniques may be applicable to either advanced, helium-cooled, refractory heat sinks or present-day, water-cooled, copper-alloy heat sinks.

In addition, grant applications are sought to develop new or improved *in situ* diagnostic techniques to monitor the health and performance of operating PFCs and plasma edge conditions. A carefully selected combination of MEMS-like, robust diagnostics could create an instrumented PFC that monitors important characteristics (such as the temperature and stress gradients) within the PFC or provides real-time information on erosion/deposition rates or tritium uptake during operation. Measurements of current, B-field, plasma edge temperature and density, spectral emissions, and heat flux also would be of interest. Such diagnostics must be an integral part of the PFC, be self-powered, operate at elevated temperatures in the presence of high magnetic fields and neutron fluence, be immune to RF noise, provide for wireless data transmission with high signal to noise ratio, and be compatible with high performance plasma operation.

Another PFC option is to use a flowing liquid metal surface as a plasma facing component, an approach which will require the production and control of thin, fast flowing, renewable films of liquid lithium, gallium, or tin for particle control at divertors. Grant applications are sought to develop: (1) techniques for the production, control, and removal of flowing (velocity 0.01 to 10 m/s) liquid metal films (0.5-5 mm thick) over a temperature controlled substrate; (2) advances in materials that are wet by liquid metals at temperatures near the respective metal melting point and that are conducive to the production of uniform well-adhered films; (3) techniques for active control of liquid metal flow and stabilization in the presence of plasma instabilities (time and space varying magnetic field); and (4) computational tools that model the flow and magnetohydrodynamic response of flowing liquid metals.

Grant applications also are sought to develop and demonstrate innovative computational techniques directly related to modeling material properties or near-surface plasma/neutral characteristics, for the purpose designing and assessing PFC materials. Finally grant applications are sought to develop cost-effective experimental techniques that integrate multiple approaches, listed in the paragraphs above, in order to allow advanced plasma-material-interaction testing and simulation.

Questions - contact Gene Nardella (gene.nardella@science.doe.gov)

b. **Blanket Materials and Systems—**The pebble-bed solid breeder configuration introduces several operational limits: thermo-mechanical uncertainties caused by pebble-bed wall interaction, potential sintering and subsequent macro-cracking, and a low pebble-bed thermal conductivity – all of which result in small characteristic bed dimensions and limit windows of operation. A new form of solid breeder morphology is required that holds the promise for increased breeding ratios – dictated by increased breeder material density; long term structural reliability; and enhanced operational control – compared to packed beds. Grant applications are sought for new solid breeder material concepts that include: (1) increased breeder material densities (>80%); (2) higher thermal conductivities (provided by a fully interconnected structure, as opposed to point contacts between pebbles); (3) better thermal contact, such as reliable bonded contact, with cooling structures (instead of point contacts between pebbles and wall); (4) the absence of major geometry changes between beginning-of-life and end-of life (such as sintering in pebble beds) in the presence of high neutron

fluence; and (5) structural integrity in freestanding and self-supporting structures with significant thermo-mechanical flexibility.

Flow channel inserts (FCIs) act as magnetohydrodynamic and thermal insulators in ferritic steel channels containing, for example, a slowly flowing tritium breeder such as molten Pb-17Li alloy. The insert geometry is approximately box-channel-shaped in straight channels, with more complex shapes possible, for insertion in manifolds and other complex-geometry elements in the flow path. Although SiC/SiC composite is a candidate FCI material, its use would differ from its potential application as a structural material in that high thermal and electrical conductivity would not be desirable. In fact, the electrical conductivity should be as low as possible, with a target range from 1 to 50 $\Omega^{-1}m^{-1}$. In addition, the strength requirements for a SiC/SiC FCI are reduced compared to the composite's application as a structural material, because the primary stresses and pressure loads will be very low. On the other hand, the insert must be able to withstand thermal stresses from temperature gradients in the range of 10-40 C/mm. Grant applications are sought to develop manufacturing techniques for radiation resistant, low thermal/electrical conductivity SiC/SiC composites that would not allow the Pb-17Li alloy to penetrate any porosity in the matrix. One approach that has been envisioned is the use of a final "sealing" layer of SiC matrix material, which would be near theoretical density and cover any porosity or exposed fibers in the main body of the insert. Two-dimensional weaves are also thought to be satisfactory, as well as an effective way to reduce electrical conductivity normal to the interface between the insert and the Pb-17Li (the more important of the directions). In addition, grant applications are sought to develop experimental techniques for determining: (1) the compatibility between the SiC/SiC composite and such breeder materials as Pb-17Li alloy, and (2) the insert integrity under cyclic thermal loading.

One of the missions of the ITER project is the integrated testing of fusion blanket modules in a true integrated fusion environment. This ITER fusion environment includes radiation and magnetic fields, along with surface and volumetric heating, under pulsed and/or steady-state plasma operation. The testing of first wall/blanket components will be performed in ITER by inserting "test blanket modules" (TBMs) that will be complicated systems of different functional materials (breeder, multiplier, coolant, structure, insulator, etc.) in various configurations with many responses and interacting phenomena (e.g., thermomechanical, thermofluid, nuclear). As part of the design and validation process an overall simulation of a "virtual" TBM, integrating all of the individual computational modeling simulations at the system level, is essential to define meaningful experiments. Such a simulation would be inherently multi-scale and multi-physics and will require careful code and algorithm design. Therefore, grant applications are sought to develop a TBM simulation code that can provide visual animations of: (1) fluid flow and thermal hydraulic characteristics; (2) the thermal response of all materials (structure, breeder, multiplier, coolant, insulator, etc); (3) structural responses such as stress and deformation magnitudes with respect to different loadings, including both steady-state surface heat flux and dynamic loadings; and (4) other important performance characteristics of the TBM. The overall code framework/structure must effectively link all of the simulation components of the virtual TBM and serve as an efficient, useful, and user-friendly tool.

Questions - contact Gene Nardella (gene.nardella@science.doe.gov)

c. Superconducting Magnets and Materials—New or advanced superconducting magnet concepts are needed for plasma fusion confinement systems; i.e., high field magnets (12 to 20 T) and low loss pulsed magnets. Grant applications are sought for: (1) innovative and advanced materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs; (2) cryogenic superconductor materials with high critical current density, low sensitivity to strain degradation effects, and radiation resistance; (3) novel, low-cost cable designs and fabrication techniques, which minimize conductor strain; (4) superconducting joints for high field and pulsed applications; (5) novel, advanced sensors and instrumentation for non-invasively monitoring magnet and helium parameters (e.g., pressure, temperature, voltage, mass flow, quench, etc.); (6) thick (15-30 cm), weldable, cryogenic structural materials with high strength and toughness at 4 K; (7) welding techniques for such thick cryogenic structural materials; and (8)

radiation-resistant electrical insulators (e.g., wrapable inorganic insulators and low viscosity organic insulators, which exhibit low out gassing under irradiation).

Questions - contact Barry Sullivan (barry.sullivan@science.doe.gov)

d. Structural Materials and Coatings—Grant applications are sought to develop methods for fabricating and joining first-wall, grid plate, and manifold structures – made of intricate, reduced-activation ferritic/martensitic (RAFM) steel – of ITER test blanket modules. The fabrication and joining procedures must produce microstructures that are resistant to the effects of neutron irradiation at temperatures from 325°C to 550°C; achieve the levels of strength, fracture toughness, creep and fatigue resistance required to ensure adequate structural margins throughout the deuterium-tritium operating phase of ITER; and meet the dimensional tolerances needed to ensure adequate heat removal characteristics.

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

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

Grant applications also are sought to develop high-toughness tungsten alloys. Areas of interest include improvements in the grain boundary strength and fracture toughness, and joining techniques.

Grant applications also are sought to develop electrically insulating coatings on vanadium (V) or RAFM steel to reduce magnetohydrodynamic effects in liquid-metal cooled systems. Proposed approaches must: (1) account for compatibility with both the coated structural alloy and liquid metal coolant for long-time operation at 400-700˚C (2) address the use of candidate coatings on actual system components; and (3) account for the long term reliability and/or *in situ* repair of defects that could develop in the coating. (Grant applications must be limited to vanadium-lithium and RAFM steel-lead lithium systems.)

Finally, grant applications are sought to develop innovative modeling tools for the above joining methods, materials, and coatings. Modeling approaches may range from atomistic and molecular dynamics simulations of atomic collision and defect migration events to improved finite element analysis or thermodynamic stability methods.

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

Questions - contact Gene Nardella (gene.nardella@science.doe.gov)

Subtopic a References:

1 Rognlien, T. D. and Rensink, M. E., "Edge Plasma Models and Characteristics for Magnetic Fusion Energy Devices," *Fusion Engineering and Design*, 60: 497, 2002. (ISSN: 0920-3796)

2 Brooks, J. N., "Modeling of Sputtering Erosion/Redeposition-Status and Implications for Fusion Design," *Fusion Engineering and Design*, 60: 515, 2002. (ISSN: 0920-3796)

3 Nygren, R.E., "Actively Cooled Plasma Facing Components for Long Pulse High Power Operation," *Fusion Engineering and Design*, 60: 547, 2002. (ISSN: 0920-3796)

4 Lorenzetto, P., et al., "EU R&D on the ITER First Wall," *Fusion Engineering and Design*, 81: 1-7, 2006. (ISSN: 0920-3796)

5 Ihli, T., et al., "Gas-Cooled Divertor Design Approach for ARIES-CS," poster presentation, 21st IEEE/NPSS Symposium on Fusion Engineering SOFC, Knoxville, TN, September 2005. (See summary at: http://www.ornl.gov/sci/fed/sofe05/summary/abs/149.pdf)

6 Coad, J.P., et al., "Diagnostics for Studying Deposition and Erosion Processes in JET," *Fusion Engineering and Design*, 74(1-4): 745-749, 2005. (ISSN: 0920-3796)

7 Mayer, M., et al., "Carbon Erosion and Migration in Fusion Devices," *Physica Scripta*, T111: 55-59, 2004. (ISSN: 0031-8949)

8 Bastasz, R. and Eckstein, W., "Plasma-Surface Interactions on Liquids," *Journal of Nuclear Materials*, 290-293: 19-24, 2001. (ISSN: 0022-3115)

9 Brooks, J. N., et al., "Overview of the ALPS Program," *Fusion Science and Technology*, 47(3): 699-677, 2005. (ISSN: 1536-1055)*

10 Abdou, M., et al., eds., "Special Issue on Innovative High-Power Density Concepts for Fusion Plasma Chambers," *Fusion Engineering and Design*, 72: 1-326, 2004. (ISSN: 0920-3796)

Subtopic b References:

1 Sharafat, S., et al., "Cellualr Foams: A Potential Solid Breeder Material for Fusion Applications," *Fusion Science and Technology*, 47(4): 886-890, May 2005. (ISSN: 1536-1055)*

2 Tillack, M. S., et al., "Fusion Power Core Engineering for the ARIES-ST Power Plant," *Fusion Engineering and Design*, 65: 215-261, 2003. (ISSN: 0920-3796)

3 Morley, N., et al., "Thermofluid Magnetohydrodynamic Issues for Liquid Breeders," *Fusion Science and Technology*, 47(3): 488-501, April 2005. (ISSN: 1536-1055)*

4 Abdous, M., et al., "U.S. Plans and Strategy for ITER Blanket Testing," *Fusion Science and Technology*, 47(3): 475-487, April 2005. (ISSN: 1536-1055)*

5 Ying, A., et al., "An Overview of U.S. ITER Test Blanket Module Program," *Fusion Engineering and Design*, 81: 433-411, 2006. (ISSN: 0920-3796)

Subtopic c References:

1 Seeber, B., ed., Handbook of Applied Superconductivity, 2 Vols., Bristol, England: Institute of Physics Publishing, January 1998. (ISBN: 0-7503-03778)

2 Lee, P., ed., "Engineering Superconductivity," New York: Wiley Interscience, 2001. (ISBN: 0-4714-11167)

3 Asner, F. M., High Field Superconducting Magnets, Oxford, England: Oxford Science Publications, 1999. (ISBN: 0-1985-17645) (Product description, including TOC, plus ordering information available at: http://www.oup-usa.org/toc/tc_0198517645.html)

4 Poole, C. P., Jr., et al., eds., Handbook of Superconductivity, Academic Press, 2000. (ISBN: 0-1256-14608) (Ordering information and full index available at: http://www.amazon.com/exec/obidos/tg/detail/-/0125614608/104-6888958-8643120?vi=glance)

5 Iwasa, Y., "Case Studies in Superconducting Magnets: Design and Operational Issues," New York: Plenum Press, 1994. (ISBN: 0-3064-48815)

Subtopic d References:

1 Bloom, E. E., et al., "Materials to Deliver the Promise of Fusion Power-Progress and Challenges," *Journal of Nuclear Material*, 329-333: 12-19, 2004. (ISSN: 0022-3115)

2 Zinkle, S. J., "Fusion Materials Science: Overview of Challenges and Recent Progress," *Physics of Plasmas*, 12(5), Article No. 058101, 2005. (Full text of tutorial available at: http://www.ms.ornl.gov/programs/fusionmatls/pdf/selectedpubs/APS-DPP%20mat%20sci%20tutorial.pdf)

3 Muroga, T., et al., "Overview of Materials Research for Fusion Reactors," *Fusion Engineering and Design*, 61-62: 13-25, 2002. (ISSN: 0920-3796)

4 Klueh, R.L., "Reduced-Activation Bainitic and Martensitic Steels for Nuclear Fusion Applications," *Current Opinion in Solid State Materials Science*, Special Issue on Bainite, 8: 239-250, 2004. (Full text available at: http://www.ms.ornl.gov/programs/fusionmatls/pdf/dec2004/3_Ferritic/Klueh.pdf)

5 Odette, G. R., et al., "Cleavage Fracture and Irradiation Embrittlement of Fusion Reactor Alloys: Mechanisms, Multiscale Models, Toughness Measurements, and Implications to Structural Integrity Assessment," *Journal of Nuclear Materials*, 323: 313-340, 2003. (ISSN: 0022-31115)

6 Barabash, V. R., et al., "Armor and Heat Sink Materials Joining Technologies Development for ITER Plasma Facing Components," *Journal of Nuclear Materials*, 283-287: 1248-1252, 2000. (ISSN: 0022-3115)

7 Wong, C. P. C., et al., "An Overview of Dual Coolant Pb-17Li Breeder First Wall and Blanket Concept Development for the US ITER-TBM Design," *Fusion Engineering and Design*, 81: 461-467, 2006. (ISSN: 0920-3796)

* (Abstract and ordering information available at: http://www.ans.org/pubs/journals/fst/vv-47. List ordered by Issue Number and Page Number.)

32. FUSION SCIENCE AND TECHNOLOGY

The Fusion Energy Sciences program currently supports several fusion experiments with many common objectives. These include expanding the scientific understanding of plasma behavior and improving the performance of high temperature plasma for eventual energy production. The goals of this topic are to develop and demonstrate innovative techniques, instrumentation, and concepts for measuring magnetic plasma parameters; for plasma processing; for magnetic plasma simulation, control, and data analysis; and for innovative approaches to fusion. It is also intended that concepts developed as part of the fusion research program will have application to industries in the private sector. Further information about research funded by the Office of Fusion Energy Sciences (OFES) can be found in the OFES Website (URL: WWW.OFES.FUSION.DOE.GOV).

Grant applications are sought only in the following subtopics:

a. U.S. ITER Diagnostics—The United States has joined the international collaboration to construct and operate ITER, a full-scale experimental fusion energy device that will pave the way to clean energy. In order for U.S.-allocated diagnostics systems to better meet the functional measurement requirements for ITER, grant applications are sought to improve some subsystem components. Components of interest include: (1) a vacuum-compatible hot calibration source, for calibration of the electron cyclotron emission diagnostic; (2) a higher efficiency frequency doubler for 10.6 micron lasers, for the ITER tangential interferometer/polarimeter system and the ITER divertor interferometer system; (3) gas composition sensors with improved time response, compatible with the ITER environment; (4) an *in situ* calibration system for the ITER motional Stark effect diagnostic; (5) a high frequency microwave source for the ITER low-field-side reflectometer system; and (6) large-area infra-red image sensors for the ITER upper camera system. Grant applications must propose the development of hardware for U.S. ITER diagnostics; all other applications will be declined.

Questions - contact Darlene Markevich (darlene.markevich@science.doe.gov)

b. Components for Heating and Fueling of Fusion Plasmas and Tokamak Facility Operations—Grant applications are sought to develop components related to the generation, transmission, and launching of high power electromagnetic waves in the frequency ranges of ion cyclotron resonance heating (50 to 300 MHz), lower hybrid resonance heating (2 to 20 GHz), and electron cyclotron resonance heating (100 to 300 GHz). Components of interests include power supplies, fault protection devices, antenna and launching systems, tuning and matching systems, unidirectional couplers, circulators, mode convertors, windows, output couplers, loads, energy extraction systems from spent electron beams and particle accelerators, and diagnostics to evaluate the performance of these components.

Grant applications also are sought to (1) develop computer codes for the simulation of maintainability/reliability assurance technologies and for plant operations, applicable to fusion experiments; and (2) apply artificial intelligence to the monitoring of tokamak plant operation, and real-time or impending fault condition.

Questions - contact Barry Sullivan (barry.sullivan@science.doe.gov)

c. Plasma Simulation and Data Analysis—The simulation of fusion plasmas is important to the development of plasma discharge feedback and control techniques. The simulations can be used to make reliable predictions of the performance of proposed feedback and control schemes and to identify those that should be tested experimentally. Unfortunately, accurate simulations of fusion plasmas are very difficult because of the enormous range of temporal and spatial scales involved in plasma behavior. Considerable progress has been made in recent years in understanding and simulating plasma turbulence, along with associated transport, macroscopic equilibrium and stability, and the behavior of the edge plasma. However, there remains a need to integrate the various plasma models. Grant applications are sought to develop computer algorithms applicable

to plasma simulations that account for an expanded number of plasma features and an integration of plasma models. Examples of possible approaches include algorithms that incorporate mathematical techniques such as neural networks, sparse linear solvers, and adaptive meshes; algorithms for coupling disparate time and space scales; efficient methods for facilitating comparison of simulation results with experimental data; and visualization tools for local and remote analysis and presentation of multi-dimensional time dependent data.

Grant applications also are sought to develop software tools useful for the analysis and distribution of fusion data. Areas of interest include methods for coupling codes across architectures and through the Internet; techniques for making highly configurable scientific codes; data management and analysis techniques for large data sets; and remote collaboration tools that enhance the ability of a geographically distributed group of scientists to interact in real-time.

The computer algorithms and programming tools should be developed using modern software techniques and should be based on the best available models of plasma behavior.

Questions - contact Rostom Dagazian (rostom.dagazian@science.doe.gov)

d. Components and Modeling Support for Innovative Approaches to Fusion—Innovative Confinement Concepts is a broad-based, long-range research activity that specifically addresses approaches that could lead to the attractive and practical use of fusion power. This research includes investigations in stellarators, spherical torus, reversed field pinches, field reversed configurations (FRC), spheromaks, magnetized target fusion, levitated dipole, flow-stabilized (long-pulse) z-pinch, rotationally stabilized magnetic mirror, and inertial electrostatic confinement, as well as innovative approaches for driving currents, injecting magnetic flux and plasmas, fuelling and controlling flow in these devices. Grant applications are sought for scientific and engineering developments, including computational modeling, in support of current experiments in these research activities, in particular for the small-scale concept exploration experiments. Further information on experiments on innovative fusion concepts is available at the OFES Website.

Questions – contact Sam Barish (sam.barish@science.doe.gov)

Subtopic a References:

1 Johnson, D., et al., The US Role in ITER Diagnostics, "Twenty-First IEEE/NPS Symposium on Fusion Engineering 2005," Sept. 2005 Page(s):1–6 (URL: http://ieeexplore.ieee.org/iel5/4018877/4018878/04018995.pdf).

2 ITER Project – U.S. ITER Diagnostics (URL: https://www.usiter.org/pro/Vendor_Fair/Posters/poster-diagnostics.pdf).

3 Because of the evolving nature of the U.S. ITER diagnostics design, please contact Darlene Markevich by e-mail at: Darlene.Markevich@science.doe.gov for the most current references.

Subtopic b References:

1 Forest, C. B., ed., 15th Topical Conference on Radio Frequency Power in Plasmas, Moran, WY, May 2003, New York: American Institute of Physics, 2003. (AIP Conference Proceedings No. 694) (ISBN: 0-7354-01586) (For abstracts of papers and ordering information, see: American Institute of Physics Conference Proceedings at: http://proceedings.aip.org/proceedings/confproceed/694.jsp)

2 Cairns, R. A. and Phelps, A. D., *Generation and Application of High Power Microwaves*, Proceedings of the Forty-Eighth Scottish Universities Summer School in Physics (SUSSP), St. Andrews, Scotland, August 1996, Institute of Physics Publishing, January 1997. (ISBN: 075030474X)

3 Temkin, R. J., ed., Twenty-Seventh International Conference on Infrared and Millimeter Waves, Conference Digest, Piscataway, NJ: IEEE Press, 2002. (IEEE Catalog Number 02EX561) (ISBN: 0-7803-74231)

4 Nusinovich, G. S., Introduction to the Physics of Gyrotrons, Baltimore, MD: Johns Hopkins University Press, July 2004. (ISBN: 0-8018-79213)

5 Callis, R. W., et al., "Maturing ECRF Technology for Plasma Control," *Nuclear Fusion*, 43(11): 1501-1504, International Atomic Energy Agency, November 2003. (ISSN: 0029-5515)(Abstract and ordering information available at: http://www.iop.org/EJ/abstract/0029-5515/43/11/022)

6 Imai, T., et al., "ITER R&D: Auxiliary Systems: Electron Cyclotron Heating and Current Drive System," *Fusion Engineering and Design*, 55(2-3): 281-289, July 2001. (ISSN: 0920-3796)(Abstract and ordering information available at: http://www.sciencedirect.com/. Under "Search for a Title," enter **journal** title, and continue search.)

Subtopic c References:

1 Chervenak, A., et al., "The Data Grid: Towards an Architecture for the Distributed Management and Analysis of Large Scientific Datasets," *Journal of Network and Computer Applications*, 23: 187-200, 2001. (Based on conference publication from Proceedings of NetStore Conference 1999) (Full text available at: http://www.globus.org/alliance/publications/papers/JNCApaper.pdf)

2 About the Data Grid: Common Component Architecture Forum Website. (URL: http://www.cca-forum.org/) and Earth System Modeling Framework Website. (URL: http://www.esmf.ucar.edu/)

3 Booth, D., et al., eds., "Web Services Architecture, W3C Working Group Note 11," February 2004. (Available at: http://www.w3.org/TR/ws-arch/)

4 Oran, E. S. and Boris, J. P., Numerical Simulation of Reactive Flow, 2nd ed., Cambridge University Press, December 2000. (ISBN: 0-5215-81753)

5 Blum, J., Numerical Simulation and Optimal Control in Plasma Physics; with Applications to Tokamaks, New York: Wiley, 1989. (Gauthier-Villars Series in Modern Applied Mathematics)(ISBN: 0-4719-21874)

6 Dawson, J. M., et al., "High Performance Computing and Plasma Physics," *Physics Today*, 46(3): 64-70, March 1993. (ISSN: 0031-9228)

Subtopic d: References:

1 "ICC2004: Innovative Confinement Concepts [Workshop]," Madison, Wisconsin, May 25-28, 2004, sponsored by U.S. DOE Office of Fusion Energy Sciences. (Abstracts and presentations available at: http://plasma.physics.wisc.edu/icc2004/html/roster.php)

2 "ICC2006: Innovative Confinement Concepts [Workshop]," Austin, Texas, February 13-16, 2006, sponsored by the U.S. DOE Office of Fusion Energy Sciences. (Abstracts and presentations available at http://icc2006.ph.utexas.edu/proceedings.php)

3 Interim Report of the Panel on Program Priorities for the Fusion Energy Sciences Advisory Committee, July 2004. (Slide presentation available at: http://www.ofes.fusion.doe.gov/more_html/FESAC07-04/HEDP.pdf)

4 "Report of the Integrated Program Planning Activity (IPPA) for the DOE's Fusion Energy Sciences Program (IPPA 2000)," U.S. DOE Office of Fusion Energy Sciences, December 2000. (Report No. DOE/SC-0028) (Full text available at: http://www.ofes.fusion.doe.gov/FusionDocuments/IPPAFinalDec00.pdf)

5 Thio, Y. C., et al., "A Concept for Directly Coupled Pulsed Electromagnetic Acceleration of Plasmas," 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Indianapolis, IN, July 7-10, 2002. (AIAA Paper No. 2002-3803)(To view first page and to order, see: http://www.aiaa.org/content.cfm?pageid=413. Search by AIAA paper number.)

6 Thio, Y. C., et al., "A Physics Exploratory Experiment on Plasma Liner Formation," *Journal of Fusion Energy*, 20: 1-11, June 2002. (ISSN: 0164-0313)

7 Cassibry, J. T., et al. "Two-Dimensional Axisymmetric Magnetohydrodynamic Analysis of Blow-By in a Coaxial Plasma Accelerator," *Physics of Plasmas*, Vol. 13, 053101, May 2006. (ISSN: 1070-664X)

33. HIGH ENERGY DENSITY PHYSICS FOR INERTIAL FUSION ENERGY

Inertial fusion seeks to produce fusion reactions by creating plasmas of extremely high density and using inertia to contain momentarily the extreme pressure generated by the fusion burning plasma. In order for inertial fusion to achieve significant energy production, it will be necessary to develop attractive physics pathways for providing the necessary conditions for ignition and burn. In turn, these conditions will require states of matter with extremely high energy density (HED). For this purpose, HED states are defined as states of matter with energy densities exceeding about 10^{11} J/m^3 and temperature exceeding 1 eV. However, the physics of matter at such high energy densities is not well established – it is an emerging field that cuts across many areas of science. Therefore, the Office of Fusion Energy Sciences (OFES) sponsors research in heavy ion beams to produce these HED states, along with studies of the physics of fast ignition and high-temperature dense magnetized plasmas. This topic seeks to supplement the on-going research activities as well as to develop new techniques for creating or studying HED states relevant to the pursuit of inertial fusion energy. Proposals for the development of innovative diagnostics in support of the research are also welcome. Further information about research funded by the Office of Fusion Energy Sciences (OFES) can be found at the OFES Website: (URL: www.ofes.fusion.doe.gov).

Grant applications are sought only in the following subtopics:

a. Beam Generation, Compression, and Focusing—In current OFES programs, ion beams are produced by induction linear accelerators with components, in order to produce, accelerate, transport, and focus beams of required energy and intensity. Over the next few years, the research will concentrate on developing intense ion sources and on studying the physics of spatial compression, neutralized transport, and focusing of the beam. Grant applications are sought to support the development of high-current, high-brightness ion sources for heavy ion induction linacs. Grant applications also are sought for research in the spatial compression and focusing of

high-current, high brightness ion beams. Approaches of interest include theoretical, computational, and/or experimental investigations.

Questions - contact Francis Thio (francis.thio@science.doe.gov)

b. Fast Ignition—The Fast Ignition concept employs two drivers to create inertial fusion: one for compression, and one for the ignition of a small portion of the compressed fuel. The main requirement and challenge for Fast Ignition is to deliver the ignition energy to the compressed fuel. In the most common approach, petawatt laser energy is nominally deposited in the coronal plasma surrounding the compressed fuel, resulting in a relativistic electron beam. Ignition depends on the successful propagation of that electron beam to the fuel and the effective heating of a small portion of that fuel. In this approach, the energy transport by relativistic electrons to the high-density fuel, in order to achieve ignition, is a key physics issue. An alternative approach, in which energetic ion beams are used as igniter beams, also is under consideration. Grant applications are sought for computational, experimental, and component development in support of these on-going Fast Ignition approaches. Grant applications that address the development of petawatt lasers are outside the scope of this solicitation and will be declined.

Questions - contact Francis Thio (francis.thio@science.doe.gov)

c. Innovative Approaches for Creating and/or Studying States of High Energy Density—Grant applications are sought to develop innovative approaches for creating and/or understanding HED states. Areas of interest include, but are not limited to: (1) transport of thermal energy, kinetic energy, momentum, and particles in these states, especially the effects of externally applied or self-generated magnetic fields on the transport processes; (2) theoretical, computational, and/or experimental investigations for creating and/or using dense, high-Mach-number, high-velocity-plasma jets/beams to create HED states; and (3) generation and studies of highly intense magnetic fields (exceeding 500 T) in dense plasmas. Grant applications that address the development of petawatt lasers are outside the scope of this solicitation and will be declined.

Questions - contact Francis Thio (francis.thio@science.doe.gov)

References:

1. ”Review of the Inertial Fusion Energy Program: Final Report to the Fusion Energy Sciences Advisory Committee,” March 29, 2004. (Report No. DOE/SC-0087)(Full text available at: http://www.ofes.fusion.doe.gov/More_HTML/FESAC_Charges_Reports.html. Scroll down page to “FESAC Documents and Meeting Dates” table. In the “March 29-30, 2004” row, select “Review of the Inertial Fusion Energy Program”.)

2. “Frontiers for Discovery in High Energy Density Physics,” Report of the National Task Force on High Energy Density Physics for the Office of Science and Technology Policy, National Science and Technology Council Interagency Working Group on the Physics of the Universe. Washington, DC: Office of Science and Technology Policy, July 20, 2004. (Full text available at: http://www.sc.doe.gov/np/program/docs/HEDP_Report.pdf)

3. “Interim Report of the Panel on Program Priorities for the Fusion Energy Sciences Advisory Committee,” July 2004. (URL: http://www.ofes.fusion.doe.gov/more_html/FESAC07-04/HEDP.pdf)

4. “15th International Symposium on Heavy Ion Inertial Fusion,” Princeton Plasma Physics Laboratory, Princeton University, Princeton, NJ, June 7-11, 2004, Program and Abstract Book, U.S. Department of

Energy, 2004. (Available at: http://nonneutral.pppl.gov/HIF04/program.php) (Proceedings in Special Issue of *Nuclear Instruments and Methods in Physics Research* - Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment, 54(1-2), May 21, 2005. Abstracts of symposium documents and ordering information available at: http://www.sciencedirect.com/science/journal/01689002)

5. Thio, Y. C. F., et al., "A Physics Exploratory Experiment on Plasma Liner Formation," *Journal of Fusion Energy*, 20: 1-11, June 2002. (ISSN: 0164-0313)

6. Thio, Y. C. F., et al., "A Concept for Directly Coupled Pulsed Electromagnetic Acceleration of Plasmas," 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Indianapolis, IN, July 7-10, 2002. (AIAA Paper No. 2002-3803)(To view first page and to order, see: http://www.aiaa.org/content.cfm?pageid=413. Search by AIAA paper number.)

7. Cassibry, J. T., et al. "Two-Dimensional Axisymmetric Magnetohydrodynamic Analysis of Blow-By in a Coaxial Plasma Accelerator," *Physics of Plasmas*, Vol. 13, 053101, May 2006. (ISSN: 1070-664X)

8. Caporaso, G. J. "Progress in Induction LINACs," Proceedings of the XX International Linac Conference, (Linac 2000), Monterey, CA, August 21-25, 2000, Stanford Linear Accelerator Center, September 2000. (Full Linac 2000 proceedings available at: http://www.slac.stanford.edu/econf/C000821. For Caparaso paper, select "Author List" on left menu, scroll down to Caparaso, and select "WE101.")

9. Cook, E. G. "Review of Solid State Modulators," Proceedings of the XX International Linac Conference, (Linac 2000), Monterey, CA, August 21-25, 2000, Stanford Linear Accelerator Center, September 2000. (Full Linac 2000 proceedings available at: http://www.slac.stanford.edu/econf/C000821. For Cook paper, select "Author List" on left menu, scroll down to Cook, and select "WE103.")

10. Grote, D. P., et al., "New Methods in WARP," Proceedings of the International Computational Accelerator Physics Conference, Monterey, CA, September 14-18, 1998, American Institute of Physics, 1998. (Full text of paper available at: http://www.slac.stanford.edu/xorg/icap98/papers/C-Tu08.pdf)

11. "Proceedings of the 12th International Symposium on Heavy Ion Inertial Fusion, Heidelberg, Germany, September 24-27, 1997," *Nuclear Instruments & Methods in Physics Research,* Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 415(1, 2), 1998. (ISSN: 0168-9002)(Special Issue)(Titles and abstracts of symposium documents available at: http://www.sciencedirect.com/science/journal/01689002)

12. "Proceedings of the 13th International Symposium on Heavy Ion Inertial Fusion," San Diego, CA, March 13-17, 2000, *Nuclear Instruments & Methods in Physics Research,* Section A, 464(1-3), 2001. (ISSN: 0168-9002) (Titles and abstracts of symposium documents available at: http://www.sciencedirect.com/science/journal/01689002)

OFFICE OF NUCLEAR PHYSICS

34. NUCLEAR PHYSICS SOFTWARE AND DATA MANAGEMENT

Large scale data storage and processing systems are needed to store, access, retrieve, distribute, and process data from experiments conducted at large facilities, such as Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) and the Thomas Jefferson National Accelerator Facility (TJNAF). The experiments at such facilities are extremely complex, involving thousands of detectors that produce raw experimental data at rates up to a GB/sec, resulting in the annual production of data sets containing hundreds of Terabytes (TB) to

Petabytes (PB). Many 10s to 100s of TB of data per year are distributed to institutions around the U.S. and other countries for analysis. Research on large scale data management systems is required to support these large nuclear physics experiments. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Large Scale Data Storage—Projections of the cost of data storage media show that magnetic disk media will soon be competitive with magnetic tape for storing large volumes of data. Because current technology keeps all disk drives powered and spinning, the infrastructure costs of operating a many-petabyte-scale disk storage system could be prohibitive. However, one characteristic of nuclear physics datasets is that most of the data is accessed infrequently. Therefore, grant applications are sought for new techniques for petabyte-scale magnetic disk systems that are optimized for infrequent data access, emphasizing lower cost and lower power usage. To the extent feasible, it is desirable that the cost should scale with the amount of data accessed rather than the total storage capacity.

Grant applications are also invited for the development of innovative storage technologies that have high reliability and low cost, and are geared toward infrequently-accessed petabyte-scale data.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

b. Large Scale Data Processing and Distribution—A recent trend in nuclear physics is to construct data handling and distribution systems using web services or data grid infrastructure software – such as Globus, Condor, and Open Grid Services (OGSA), which is based upon Web Services – for large scale data processing and distribution. Grant applications are sought for: (1) hardware and/or software techniques to improve the effectiveness and reduce the costs of storing, retrieving, and moving such large volumes of data, including, but not limited to, automated data replication coupled with application data catalogs, distributed storage systems of commercial off-the-shelf (COTS) hardware, and storage buffers coupled to 10 Gbps (or greater) networks; (2) hardware and/or software techniques to improve the effectiveness of computational and data grids for nuclear physics – examples include integrating the management of distributed open source Relational DataBase Management System (RDBMS) with OGSA, and developing application-level monitoring services for status and error diagnosis; (3) effective new approaches to data mining, automatic structuring of data and information, and facilitated information retrieval; and (4) distributed authorization and identity management systems enabling single sign-on access to data distributed across many sites. Proposed infrastructure software solutions should consider and address the advantages of integrating closely with the OGSA and other new technologies. Applicants that propose data distribution and processing projects are encouraged to contact the Open Science Grid to determine relevance and possible future migration strategies into existing infrastructures.

Grant applications also are sought: (1) to provide redundancy and increased reliability for servers employing parallel architecture, so that they are capable of handling large numbers of simultaneous requests by multiple users; and (2) for hardware and software to improve remote user access to computer facilities at Nuclear Physics research centers, while at the same time providing adequate security to protect the servers from unauthorized access.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

c. Large Scale Data Archiving and Maintenance—One of the legacies of nuclear physics experiments is the data produced. Large projects like Gammasphere, sited at Argonne National Laboratory (ANL), and experiments at RHIC and TJNAF produce unique data, whose measurements may never be repeated. It may

take several years to complete the data analysis and publish the results. Then, in subsequent years, there may be a need to present the data in different forms, in order to facilitate comparison with new theoretical descriptions or newer experimental measurements. Therefore, it is important to preserve these data and their documentation over many years, in the context of potential changes in storage technology and the evolution of experimental groups. Grant applications are sought to develop permanent archiving, data provenance, and user-friendly Internet dissemination procedures for the data from nuclear physics experiments, along with associated detector description and calibration information. A complete data package would include: (1) the raw data and the programs to read and process the data; (2) ROOT trees or n-tuples with derived physics quantities; and (3) documentation, analysis notes, email archives, and web pages that detail the information and procedures used with the data for existing results. Examples of relevant technologies include (but are not limited to) systems for collecting, recording and preserving data-provenance metadata; tools to verify data integrity over long lifetimes; annotation tools; and data access portals to enable searching and retrieving relevant and related data and metadata. Applicants that propose data archiving projects are encouraged to contact the U.S. National Nuclear Data Center to determine relevance and possible future migration strategies into existing infrastructures.

Grant applications also are sought for hardware and/or software techniques to implement massive and automated backup solutions, in order to protect valuable experimental data and programs from disk failures.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

d. Grid Computing—Grid computing, sometimes called "computing on demand," is an emerging mode of supporting the highly distributed and intensive scientific computing for nuclear physics (and other sciences). Consequently, there is a need for compatible software distribution and installation mechanisms that can be automated and scaled to the large numbers (100s) of computing facilities distributed around the country and the globe. Such software solutions would enable rapid access to computing resources as they become available to users who do not have the necessary application software environment installed. Grid deployments such as the Open Science Grid (OSG) in the U.S. and the Large Hadron Collider (LHC) Computing Grid (LCG) in Europe provide standardized infrastructures for scientific computing across large numbers of distributed facilities. Grant applications are sought to develop mechanisms and tools that enable efficient and rapid packaging, distribution, and installation of nuclear physics application software on distributed computing facilities such as the OSG and LCG.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

References:

1. Firestone, R. B., "Nuclear Structure and Decay Data in the Electronic Age," *Journal of Radioanalytical and Nuclear Chemistry*, 243:77-86, January 2000. (ISSN: 0236-5731)

2. Grossman, R. L., et al., "Open DMIX - Data Integration and Exploration Services for Data Grids, Data Web, and Knowledge Grid Applications," *Proceedings of the First International Workshop on Knowledge Grid and Grid Intelligence (KGGI 2003)*, pages 16-28, 2004. (Draft of paper available at: http://www.rgrossman.com/dl/proc-077.pdf)

3. *CHEP06: Computing in High Energy and Nuclear Physics 2006 Conference Proceedings, Mumbai, India, February 13-17, 2006* Website. (URL: http://indico.cern.ch/conferenceTimeTable.py?confId=048).

4. Maurer, S. M., et al., "Science's Neglected Legacy," *Nature*, 405:117-120, May 11, 2000. (ISSN: 0028-0836) (See www.nature.com and search by title of article.)

5. Watson, C., *High Performance Cluster Computing with an Advanced Mesh Network*, Thomas Jefferson National Accelerator Facility. (URL: www.jlab.org/hpc/docs/Mesh-whitepaper.htm)

6. National Computational Infrastructure for Lattice Quantum Chromodynamics Website, (URL www.usqcd.org/)

7. Scientific Discover Through Advanced Computing, *SciDAC*, U.S. Department of Energy. (URL: www.scidac.gov/physics/quarks.html)

8. The Globus Alliance Website, University of Chicago and Argonne National Laboratory. (URL: www.globus.org)

9. Condor: High Throughput Computing Website, University of Wisconsin. (URL: www.cs.wisc.edu/condor/)

10. Towards Open Grid Services Architecture Website, University of Chicago. (URL: www.globus.org/ogsa)

11. Web Services Description Language Website, World Wide Web Consortium. (URL: http://www.w3.org/TR/wsdl)

12. Open Science Grid and the Open Science Grid Consortium Web site, National Science Foundation and U.S. Department of Energy. (URL: http://www.opensciencegrid.org/),

13. LHC [Large Hadron Collider] Computing Grid. (URL: http://lcg.web.cern.ch/LCG/)

14. EGEE [Enabling Grids for E-sciencE]. (URL: http://www.eu-egee.org/)

15. U.S. National Nuclear Data Center. (URL: http://www.nndc.bnl.gov/)

35. NUCLEAR PHYSICS ELECTRONICS DESIGN AND FABRICATION

The DOE seeks developments in detector instrumentation electronics with improved energy, position, timing resolution, sensitivity, rate capability, stability, dynamic range, durability, pulse-shape discrimination capability, and background suppression. Of particular interest are innovative readout electronics for use with the nuclear physics detectors described in Topic 37 (Nuclear Instrumentation, Detection Systems, and Techniques). All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Advances in Digital Electronics—Digital signal processing electronics are needed to replace analog signal processing in nuclear physics applications. Grant applications are sought to develop: (1) digital pulse processors that simplify or replace analog designs and have sufficient flexibility to incorporate such features as pile-up rejection and ballistic deficit correction; (2) digital pulse-processing electronics, including pulse-shape discrimination, for commonly used nuclear physics detectors in general, and for position-sensitive solid-state detectors or highly segmented CdZnTe detectors in particular; and (3) fast digital processing electronics that improve the accuracy of the analog electronics, such as in determining the position of interaction points (of particles or photons) to an accuracy smaller than the size of the detector segments.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

b. Circuits—Grant applications are sought to develop custom-designed integrated circuits, as well as circuits (including firmware) and systems, for rapidly processing data from highly segmented, position-sensitive germanium detectors (pixel sizes of approximately 1 cm^2) and from particle detectors (e.g., gas detectors, scintillation counters, silicon drift chambers, silicon strip detectors, particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Areas of specific interest include: (1) representative circuits such as low noise preamplifiers, amplifiers, peak sensors, analog storage devices, analog-to-digital and time-to-digital converters, transient digitizers, and time-to-amplitude converters; (2) multiple-sampling application-specific integrated circuits (ASICs), to allow for pulse-shape analysis; (3) readout electronics for solid-state pixilated detectors, including interconnection technologies and amplifier/sample-and-hold integrated circuits; and (4) constant-fraction discriminators with uniform response for low and high energy gamma rays. These circuits should be fast; low-cost; high-density; configurable in software for thresholds, gains, etc.; easy to use with commercial auxiliary electronics; low power; compact; and efficiently packaged for multi-channel devices.

In addition, planned luminosity upgrades at RHIC will require fine-grained vertex and tracking detectors (both silicon and gas) for high particle multiplicity environments. Therefore, grant applications are sought for advances in microelectronics that are specifically designed for low-noise amplification and processing of detector signals, and that are suitable for these next generation detectors. The microelectronics and associated interconnections must be lightweight and have low power dissipation. Of particular interest are designs that minimize higher-gate leakage currents due to tunneling and maintain dynamic range.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

c. Advanced Devices and Systems—Active Pixel Sensors in CMOS (complementary metal-oxide semiconductor) technology are replacing Charge Coupled Devices as imaging devices and cameras for visible light. Several laboratories are exploring the possibility of using such devices as direct conversion particle detectors. The charge produced by an ionizing particle in the epitaxial layer is collected by diffusion on a sensing electrode in each pixel. The charge is amplified by a relatively-simple low-noise circuit in each pixel and read out in a matrix arrangement. If successful, this approach would make possible high-resolution, position-sensitive particle detectors with very low mass (approximately 50 microns of silicon in a single layer). This approach would be superior to the present technology that uses a separate silicon detector layer, which is bump-bonded to a CMOS readout circuit. Grant applications are sought to advance the development of integrated detector-electronics technology, using CMOS monolithic circuits as particle detectors. The new active pixel detector with its integrated electronic readout should be based on a standard CMOS process. The challenge is to design a sensor with low noise readout circuits that have sufficiently high sensitivity and low power dissipation, in order to detect a minimum ionizing particle in a thin "epitaxial-like" or equivalent layer (~10-30 microns).

Grant applications also are sought for the next generation of active pixel, or even strip, sensors which use the bulk silicon substrate as the active volume. This more advanced approach would have the advantage of developing relatively larger signals and allowing sensitivity to non-minimum ionizing particles such as MeV-range gamma rays.

Lastly, grant applications are sought for improved or advanced devices and systems used in conjunction with the electronic circuits and systems described in subtopics a and b. Areas of interest regarding these devices include radiation-hardened, wide-bandgap semiconductors (i.e., semiconductor materials with bandgaps greater than 2.0 electron volts, including Silicon Carbide (SiC), Gallium Nitride (GaN), and any III-Nitride alloys), inhomogeneous semiconductors such as SiGe; and device processes such as silicon-on-insulator (SOI) or silicon-on-sapphire (SOS). Areas of interest regarding systems include bus systems, data links, event handlers, multiple processors, trigger logics, and fast buffered time and analog digitizers. For detectors that generate

extremely high data volumes (e.g., >500 GB/s), advanced high-bandwidth data links are of interest. Also of interest are generalized software and hardware packages, with improved graphic and visualization capabilities, for the acquisition and analysis of nuclear physics research data.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

d. Manufacturing and Advanced Interconnection Techniques—Grant applications are sought to develop: (1) manufacturing techniques for large, thin, multiple-layer printed circuit boards (PCBs) with plated-through holes, dimensions from 2m x 2m to 5m x 5m, with thickness from 100 to 200 microns (these PCBs would have use in cathode pad chambers, cathode strip chambers, time projection chamber cathode boards, etc); (2) techniques to add plated-through holes in a reliable, robust way to large rolls of metallized mylar or kapton (this would have applications in detectors such as time expansion chambers or large cathode strip chambers); and (3) miniaturization techniques for connectors and cables with 5 times to 10 times the density of standard interdensity connectors.

In addition, many next-generation detectors will have highly segmented electrode geometries with 5-5000 channels per square centimeter, covering areas up to several square meters. Conventional packaging and assembly technology cannot be used at these high densities. Grant applications are sought to develop: (1) advanced microchip module interconnect technologies that address the issues of high density, area-array connections including modularity, reliability, repair/rework, and electrical parasites; (2) technology for aggregating and transporting the signals (analog and digital) generated by the front-end electronics, and for distributing and conditioning power and common signals (clock, reset, etc.); (3) low-cost methods for efficient cooling of on-detector electronics; (4) low-cost and low-mass methods for grounding and shielding; and (5) standards for interconnecting ASICs (which may have been developed by diverse groups in different organizations) into a single system for a given experiment – these standards should address the combination of different technologies, which utilize different voltage levels and signal types, with the goal of reusing the developed circuits in future experiments.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

References:

1. *Conceptual Design Report for the Solenoidal Tracker at RHIC*, Lawrence Berkeley Laboratory, June 15, 1992. (Report No. LBL-PUB-5347) (NTIS Order No. DE92041174)*

2. *PHENIX Conceptual Design Report: An Experiment to be Performed at the Brookhaven National Laboratory Relativistic Heavy Ion Collider,* Brookhaven National Laboratory, January 29, 1993. (Report No. BNL-48922) (NTIS Order No. DE93015759)*

3. *Proceedings of the Tenth International Workshop on Low Temperature Detectors, Genoa, Italy, July 7-11, 2003*, "Nuclear Instruments and Methods in Physics Research, Section A--Accelerators, Spectrometers, Detectors and Associated Equipment", Vol. 520, March 2004. (ISSN: 0168-9002)

4. *Proceedings of the Workshop on the Experimental Equipment for an Advanced ISOL Facility, Berkeley, CA, July 22-25, 1998*, I.-Y. Lee, ed., Lawrence Berkeley National Laboratory (LBNL), August 15, 1998. (Report No. LBNL-42138) (Available via interlibrary loan only. Cannot be loaned to individuals. Please check with your local library about initiating request.) (1999 summary of proceedings, including recommendations, available at: http://www.orau.org/ria/detector-03/pdf/LBL-Det-workshop-final.pdf)

5. Deptuch, G., et al., "Development of Monolithic Active Pixel Sensors for Charged Particle Tracking," Nuclear Instruments and Methods in Physics Research, Section A--Accelerators, Spectrometers, *Detectors and Associated Equipment*, 511**:**240, Sept.-Oct. 2003. (ISSN: 0168-9002)**

6. A. Ionascut-Nedelcescu *et al*., "Radiation Hardness of Gallium Nitride," *IEEE Transactions on Nuclear Science*, 49:2733 2002. (ISSN: 0018-9499)

7. J.R. Dodd, *et al*., "Charge Collection in SOI (Silicon-on-Insulator) capacitors and circuits and its effect on SEU (Single-Event Upset) hardness," *IEEE Transactions on Nuclear Science*, 49:2937, 2002. (ISSN: 0018-9499)

8. 2003 IEEE Nuclear Science Symposium and Medical Imaging Conference, Portland, OR, October 19-25, 2003, 2003 IEEE Nuclear Science Symposium Conference Records, section on "High-Density Detector Processing and Interconnect," IEEE Nuclear & Plasma Society. (Print edition ISBN: 0-7803-82579; CD-ROM ISBN: 0-7803-82587)

9. Vetter, K., et al., eds., *Report of Workshop on Digital Electronics for Nuclear Structure Physics, Argonne, IL, March 2-3, 2001*. (Full text available at: http://radware.phy.ornl.gov/dsp_work.pdf).

10. Polushkin,V., Nuclear Electronics: Superconducting Detectors and Processing Techniques, J. Wiley, 2004. (ISBN: 0-470-857595) (Book description and ordering information available at www.amazon.com)

* Abstract and ordering information available from National Technical Information Service (NTIS). Telephone: 1-800-553-6847. Web site: http://www.ntis.gov/ (Search by order no. Please note: Items that are unavailable via the Web site might be obtained by phoning NTIS.)

** Abstract and ordering information available at: http://www.sciencedirect.com/science/publications/journal/physics

36. NUCLEAR PHYSICS ACCELERATOR TECHNOLOGY

The Nuclear Physics program supports a broad range of activities aimed at research and development related to the science, engineering, and technology of heavy-ion, electron, and proton accelerators and associated systems. Research and development is desired that will advance fundamental accelerator technology and its applications to nuclear physics scientific research. Areas of interest include the basic technologies of the Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC), with heavy ion beam energies up to 100 GeV/amu and polarized proton beam energies up to 250 GeV; technologies associated with RHIC luminosity upgrades; the development of an electron-ion collider (EIC); linear accelerators such as the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF); and development of devices and/or methods that would be useful in the generation of intense rare isotope beams for the next generation rare isotope beam accelerator facility. A major focus in all of the above areas is superconducting radio frequency (RF) acceleration and its related technologies. Relevance of applications to nuclear physics must be explicitly described. Grant applications that propose using the resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization.

Grant applications are sought only in the following subtopics.

a. Materials and Components for Radio Frequency Devices—Grant applications are sought to improve or advance superconducting and room-temperature materials or components for RF devices used in particle accelerators. Areas of interest include: (1) peripheral components, for both room temperature and superconducting structures, such as ultra high vacuum seals, terminations, high reliability radio frequency windows using alternative materials (e.g., sapphire), RF power couplers, and magnetostrictive cavity tuning mechanisms; (2) alternative cavity fabrication techniques, such as hydroforming or spinning of seamless SRF cavities; (3) fast ferroelectric microwave components that control reactive power for fast tuning of cavities or fast control of input power coupling; (4) materials that efficiently absorb microwaves from 2 to 90 GHz and are compatible with ultra-high vacuum, particulate-free environments at 2 to 4 K; (5) methods for manufacturing superconducting radio-frequency (>500 MHz) accelerating structures with $Q_0>10^{10}$ at 2.0 K, or with correspondingly higher Q's at higher temperatures such as 4.5 K; (6) improved superconducting materials that have lower RF losses, operate at higher temperatures, and/or have higher RF critical fields than sheet niobium; (7) innovative designs for hermetically sealed helium refrigerators and other cryogenic equipment, which simplify procedures and reduce costs associated with repair and modification; (8) more cost effective, kW-to-multiple-kW level, liquid helium refrigerators; (9) simple, low-cost mechanical techniques for damping length oscillations in accelerating structures, effective in the 10-300 Hz range at 2 and/or 4.5 K; (10) techniques to create a layer of niobium on the interior of a copper elliptical cavity, such as by energetic ion deposition, so that the resulting 700-1500 MHz structures have $Q_0>8 \times 10^9$ at 2 K; and (11) advanced techniques for surface processing of superconducting resonators, including methods for electropolishing, high temperature treatments, and surface coatings that enhance or stabilize performance parameters.

Grant applications also are sought to develop designs, computer-modeling, and hardware for 5-20 kW continuous wave (cw) power sources at distinct frequencies in the range of 50-1500 MHz, and for 1 MW cw RF power sources at 704 MHz. Examples of candidate technologies include: solid-state devices, multi-cavity klystrons, Inductive-Output Tubes (IOTs), or hybrids of those technologies. Computer software for the design or modeling of any of these devices also is sought; such software should be able to faithfully model the complex shapes with full self-consistency. In addition, software that integrates multiple effects, such as electromagnetic and wall heating, is desired. Interested parties should contact Dr. Leigh Harwood at Thomas Jefferson Laboratory (harwood@jlab.org), Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (ilan@bnml.gov), or Dr. Jerry Nolen at Argonne National Laboratory (Nolen@ANL.gov) for further specifications.

Questions - contact Mouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

b. Design and Operation of Radio Frequency Beam Acceleration Systems—Grant applications are sought for the design, fabrication, and operation of radio frequency accelerating structures and systems for electrons, protons, light- and heavy-ion particle accelerators. Areas of interest include: (1) continuous wave (cw) structures, both superconducting and non-superconducting, for the acceleration of beams in the velocity regime between 0.001 and 0.03 times the velocity of light, and with charge-to-mass ratios between 1/6 and 1/240; (2) superconducting RF accelerating structures appropriate for rare isotope beam accelerator drivers, for particles with speeds in the range of 0.02-0.8 times the speed of light; (3) innovative techniques for field control of ion acceleration structures (1º or less of phase and 0.1% amplitude) and electron acceleration structures (0.1º of phase and 0.01% amplitude) in the presence of 10-100 Hz variations of the structures' resonant frequencies (0.1-1.5 GHz); (4) multi-cell, superconducting, 0.5-1.5 GHz accelerating structures that have sufficient higher-order mode damping, for use in energy-recovering linac-based devices with ~1 A of electron beam; (5) methods for preserving beam quality by damping beam-break-up effects in the presence of otherwise unacceptably-large, higher-order cavity modes – one example of which would be a very high bandwidth feedback system; (6) development of tunable superconducting RF cavities for acceleration and/or storage of relativistic heavy ions; (7) multi-cell superconducting 1.5 GHz deflecting RF structures with sufficient higher order mode damping, for use as crab cavities for protons and ions in an electron ion collider; and (8) advanced parallel-computing simulation techniques for the optimization of both normal- and super-conducting accelerating structures for the future rare isotope facility.

Grant applications also are sought to develop and demonstrate low level RF system control algorithms or control hardware that provide a robust and adaptive environment suitable for any RF system. Of special interest are approaches that address the particular challenges of superconducting RF systems, but room temperature systems are of interest as well.

Finally, software for the design and modeling of the above systems also is sought. Desired modeling capabilities include: charged particle dynamics in complex shapes including energy recovery analysis; the incorporation of complex fine structures, such as higher order mode dampers; the computation of particle- and field-induced heat loads on walls; the incorporation of experimentally measured 3-D charge and bunch distributions; and the simulation of the electron cloud effect and its suppression. Interested parties should contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (ilan@bnl.gov).

Questions - contact Mouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

c. Particle Beam Sources and Techniques—Grant applications are sought to develop: (1) particle beam ion sources with improved intensity, emittance, and range of species; (2) ion sources for radioactive beams; (3) methods and/or devices for reducing the emittance of relativistic ion beams – such as electron or optical-stochastic cooling; (4) techniques for secondary radioactive beam collection, charge equilibration, and cooling; (5) technology for stopping energetic radioactive ions in helium gas and extracting them efficiently as high-quality low-energy ion beams; (6) methods and devices to increase the charge state of ion beams (e.g., by the use of special electron-cyclotron-resonance ionizers, electron-beam ionizers, or special stripping techniques); (7) polarized hydrogen and deuterium (H-/D-) sources with polarization above 90%; (8) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients; (9) ~1 GHz cw polarized electron sources delivering beams of ~10 mA, with longitudinal polarization greater than 80%; (10) ~28 MHz cw polarized sources delivering beams of ~500 mA with polarization greater than 80%; (11) devices, systems, and sub-systems for producing high current (>200μA), variable-helicity beams of electrons with polarizations greater than 80%, and which have very small helicity-correlated changes in beam intensity, position, angle, and emittance; (12) methods to improve high voltage stand-off and reduce field emission from high voltage electrodes, compatible with ultra-high-vacuum environments; (13) wavelength-tunable (700 to 850 nm) mode-locked lasers, with pulse repetition rate between 0.5 and 3 GHz and average output power >10 W; (14) a high-average-power (~100 W), green laser light source, with a RF-pulse repetition rate in the range of 0.5 to 3 GHz for synchronous photoinjection of GaAs photoemission guns; and (15) a cost-effective means to obtain and measure vacuum below 10^{12} Torr. For questions related to polarized electron source applications, contact Dr. M. Poelker at Thomas Jefferson Laboratory (poelker@jlab.org).

Grant applications also are sought to develop advanced simulation methods for charged particle sources leading to the optimization of parameters and improved performance of a variety of source types used in nuclear physics.

Grant applications are sought to develop advanced and innovative approaches to the construction of large aperture superconducting and/or room temperature magnets, for use in fragment separators and magnetic spectrographs at rare isotope beam accelerator facilities. Special designs that are applicable for use in high radiation areas also are sought. (Additional needs for high-radiation applications can be found in subtopic "d" of Topic 37, Nuclear Physics Detection Systems, Instrumentation and Techniques.)

Grant applications are sought to develop technology for electron rings of future electron-ion colliders, which will operate with very high synchrotron radiation power. These rings should be flexible to accommodate a large range of energy adjustment and electron beam spin manipulation. Of particular interest is the development of radiation adjustable dipole magnets, which will allow large energy changes while maintaining high synchrotron

radiation power for strong synchrotron radiation damping and short self-polarization duration. Interested parties should contact Dr. Fuhua Wang at MIT-Bates Research and Engineering Center (fwang@mit.edu) for further information.

Grant applications also are sought for: (1) advanced software and hardware to facilitate the manipulation and optimized control of spin polarized beams; (2) advanced beam diagnostic concepts, including new beam polarimeters and fast reversal of stored, polarized beams; (3) novel concepts for producing polarizing particles of interest to nuclear physics research, including electrons, positrons, protons, deuterons, and ^{3}He; (4) development of sophisticated computer software for tracking spin polarized particles in storage rings and colliders; and (5) the design and construction of novel magnet systems for spin polarized beams, including wigglers, Siberian snakes, and superbenders.

Grant applications also are sought to develop new methods of intense beam acceleration, including technology for proton and electron acceleration in the energy range of several GeV, using non-scaling fixed-field alternating gradient accelerators (FFAG). Areas of interest include: (1) development of rapidly tunable RF systems, (2) demonstration of appropriate magnetic field configurations, and (3) design of an electron model/prototype to directly simulate operation under space-charge-limiting conditions. The nuclear physics interest is the acceleration of charged particles in re-circulating devices. Other potential applications of FFAG include high-intensity proton drivers for neutron production, waste transmutation, energy production in nuclear reactors, medical proton therapy (250 MeV), and radioisotope production. Interested parties should contact Dr. Dejan Trbojevic at Brookhaven National Laboratory (trbojevic@bnl.gov) for further information.

Lastly, grant applications are sought to develop software that adds significantly to the state-of-the-art in the simulation of beam physics, including intra-beam scattering, spin dynamics, polarized beam generation, electron cooling, beam dynamics, transport and instabilities, and electron or plasma discharge in vacuum under the influence of charged beams. The software should use modern best practices for software design, should run on multiple platforms, and should run in both serial and parallel configurations. Graphical user interfaces for problem definition and setup also are sought. Interested parties should contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (ilan@bnl.gov) and/or Dr. Lia Merminga at Thomas Jefferson Laboratory (merminga@jlab.org)

Questions - contact Mouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

d. Accelerator Control and Diagnostics—Grant applications are sought for: (1) "intelligent" software and hardware to facilitate the improved control and optimization of charged particle accelerators and associated components for nuclear physics research (developments that offer generic solutions to problems with respect to the initial choice of operation parameters and the optimization of selected beam parameters with automatic tuning are especially encouraged); (2) advanced beam diagnostics concepts and devices that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum profile, time of arrival, and energy (including such advanced methods as neural networks or expert systems and techniques that are nondestructive to the beams being monitored); (3) beam diagnostic devices that have increased sensitivities through the use of superconducting components (for example, filters based on high T_c superconducting technology or Superconducting Quantum Interference Devices); (4) measurement devices/systems for cw beam currents in the range 0.1 to 100 μA, with very high precision ($<10^{-4}$) and short integration times; (5) beam diagnostics for ion beams with intensities less than 10^7 nuclei/second; (6) non-destructive beam diagnostics for stored ion beams such as at the RHIC and/or for 100 mA class electron beams; (7) devices that can perform direct 12-14 bit digitization of signals at 0.5-2 GHz and have bandwidths of 100+ kHz; (8) systems for predicting insipient failure of accelerator components through the monitoring/cataloging/scanning of real-time or logged signals; (9) devices/systems that measure the emittance of intense (>100kW) cw ion beams, such as those expected at a future rare isotope beam facility; (10)

beam halo monitor systems for ion beams and (11) instrumentation for electron cloud effect diagnostics and suppression..

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

References:

1. Padamsee, H., *RF Superconductivity – 2004*, Cornell University. (URL: http://www.lns.cornell.edu/~preprint/hasan/BrochureOriginal.pdf)

2. *Application of Accelerators in Research and Industry, Proceedings of the Seventeenth International Conference*, Duggan, J. L. and Morgan, I. L., eds., Denton, TX, November 12-16, 2002, New York: American Institute of Physics, 2003. (ISBN: 0-7354-01497) (AIP Conference Proceedings No. 680)*

3. Litvinenko, V. L., et al., "Gamma-Ray Production in a Storage Ring Free-Electron Laser," *Physical Review Lett*ers, 78:4569, 1997. (ISSN: 0031-9007)

4. Gamp, A., et al., "Design of the RF Phase Reference System and Timing Control for the TESLA Linear Collider", *Proceedings of* the XIX International Linear Accelerator Conference, Chicago, IL, August 23-28, 1998, pg. 204, 1998. (Full text available at: http://accelconf.web.cern.ch/accelconf/l98/Proceedings.html. Search Author Index.)

5. Champion, M., et al., "The Spallation Neutron Source Accelerator Low Level RF Control System", *Proceedings of 2003 Particle Accelerator Conference, Portland, OR, May 12-16, 2003*, p. 3377, 2003. (Full text available at: http://accelconf.web.cern.ch/accelconf/p03/INDEX.HTM. Search Author Index.)

6. Kandil, T., et al., "Adaptive Feedforward Cancellation of Sinusoidal Disturbances in Superconducting RF Cavities", p. 447, *Proceedings of XXII International Linear Accelerator Conference*, Lübeck, Germany, August 16-20, 2004. (Full text available at: http://accelconf.web.cern.ch/accelconf/l04/HTML/BANNER.HTML. Search Authors' Index)

7. *CEBAF @ 12 GeV: Future Science at Jefferson Lab* Website, Thomas Jefferson National Accelerator Laboratory. (URL: http://www.jlab.org/12GeV/)

8. Chew, J., et al., eds., *Proceedings of 2003 Particle Accelerator Conference, Portland, OR, May 12-16, 2003*, p. 3377, 2003. (Full text available at: http://accelconf.web.cern.ch/accelconf/p03/INDEX.HTM)

9. *eRHIC: The Electron-Ion-Collider at BNL*, Website, U.S. DOE Brookhaven National Laboratory. (URL: http://www.phenix.bnl.gov/WWW/publish/abhay/Home_of_EIC/)

10. "Design studies of a high-luminosity ring-ring electron ion collider at CEBAF", A. Bogacz, et.al. Proceedings of PAC 2007, Albuquerque, NM, June 25-19, 2007.
(the URL for ELIC is http://casa.jlab.org/research/elic/elic.shtml and the ELIC Zeroth order design review can be found at http://casa.jlab.org/research/elic/elic_zdr.doc)

11. Freeman, H., "Heavy-Ion Sources: The Star, or the Cinderella, of the Ion-Implantation Firmament?" *Review of Scientific Instruments*, 71**:**603, February 2000. (ISSN: 0034-6748)

12. Ben-Zvi, I., et al., "R&D Towards Cooling of the RHIC Collider," *Proceedings of the 2003 Particle Accelerator Conference, Portland, OR, May 12-16, 2003*. (Full text available at: http://accelconf.web.cern.ch/accelconf/p03/INDEX.HTM)

13. *Proceedings of the 2003 RIA R&D Workshop, Bethesda, MD, August 26-28, 2003*. (Workshop Presentations available at: http://www.orau.org/ria/r&dworkshop/present.htm) (40-page formal report of Workshop available at: http://www.pubs.bnl.gov/documents/25894.pdf)

14. Nolen, J.A., *"Plans for an Advanced Exotic Beam Facility in the U.S.,"* Nuclear Physics A787 (2007) 84c. (Full text available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TVB-4NKKM8B-D&_user=10&_coverDate=05%2F01%2F2007&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=c83edaf6954da23c9dbc39f2b2d9b1ff)

15. Trbojevic, D., et al., "Design of a Nonscaling Fixed Field Alternating Gradient Accelerator," *Physical Review Special Topics—Accelerators and Beams,* 8:050101, 2005. (See http://prst-ab.aps.org/search. Scroll down page and search by author and title.)

* Book description and ordering information available from Springer-Verlag New York, Inc. Website: http://www.springer-ny.com/aip/

37. NUCLEAR PHYSICS INSTRUMENTATION, DETECTION SYSTEMS AND TECHNIQUES

The Office of Nuclear Physics is interested in supporting projects that may lead to advances in detection systems, instrumentation, and techniques for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art and outside the usual scope of research and development activities at the nuclear physics national laboratories and university programs. In addition, a new suite of next-generation detectors will be needed for future rare isotope beam capabilities, the 12 GeV CEBAF Upgrade at TJNAF, the proposed underground laboratory by the National Science Foundation, the proposed luminosity upgrade at RHIC, the proposed facility for rare isotope beams, and a possible future electron-ion collider. Also of interest is technology related to future experiments in fundamental symmetries, such as neutrinoless double-beta decay experiments and measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detections are essential. Lastly, this topic seeks state-of-the-art targets for applications ranging from spin polarized and unpolarized nuclear physics experiments to stripper and production targets required at high-power, advanced, rare isotope beam facilities. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Advances in Detector and Spectrometer Technology—Nuclear physics research has a need for devices to detect, analyze, and track charged particles, and neutral particles such as neutrons, neutrinos, photons, and single atoms. These devices include: solid-state devices such as highly segmented coaxial and planar germanium detectors, and silicon strip, pixel, silicon 3D devices and silicon drift detectors; photosensitive devices such as avalanche photodiodes, hybrid photomultiplier devices, single and multiple anode photomultiplier tubes, silicon-based photomultipliers, high-intensity (~10^{20} γ/s) gamma-ray current-readout detectors (e.g. Compton Diodes), photodiodes for operation at liquid helium temperatures with a signal-to-noise ratio comparable to a photomultiplier tube, photomultiplier tubes designed to work in a liquid helium environment, and other novel photon detectors; detectors utilizing photocathodes for Cherenkov and UV light detection, and the development of new types of large area photo-emissive materials such as solid, liquid, or gas photocathodes; micro-channel plates; gas-filled detectors such as proportional, drift, streamer, microstrip, Gas Electron Multipliers (GEMs), Micromegas and other types of micropattern detectors, straw drift tube detectors, time projection chambers, resistive plate chambers, and Cherenkov detectors; liquid argon and xenon ionization

chambers and other cryogenic detectors; single-atom detectors using laser techniques and electromagnetic traps; particle polarization detectors; electromagnetic and hadronic calorimeters, including high energy neutron detectors; and detection systems for detecting the magnetization of polarized nuclei in a magnetic field (e.g., Superconducting Quantum Interference Devices (SQUIDs) or cells with paramagnetic atoms that employ large pickup loops to surround the sample).

Grant applications are sought to develop advancements in the technology of the above mentioned detectors. In addition, grant applications are sought to develop devices designed to perform precision calibration of these detectors. Such devices include novel, controllable calibration sources for electrons, gammas, alphas, and neutrons; pulsed calibration sources for neutrons, gammas, and electrons; precision charged particle beams, and pulsed UV optical sources.

With respect to solid state tracking devices, such as the segmented germanium detectors and the silicon drift, strip, and pixel detectors, grant applications are sought for: (1) manufacturing techniques, including interconnection technologies for high granularity, high resolution, light-weight, and radiation-hard solid state devices; (2) highly arrayed solid state detectors for neutron detection, with integrated electronics to read-out pulse height; (3) thicker (more than 1.5 mm) segmented silicon charged-particle and x-ray detectors and associated high density, high resolution electronics; and (4) cost-effective production of n-type and p-type silicon drift chambers with active areas greater than 16 cm^2.

With respect to position-sensitive charged particle and photon tracking devices, grant applications are sought for the development of: (1) position-sensitive, high-resolution germanium detectors capable of determining the position (to within a few millimeters utilizing pulse shape analysis) and energy of individual interactions of gamma-rays (with energies up to several MeV), hence allowing for the reconstruction of the energy and path of individual gamma-rays using tracking techniques; (2) hardware and software needed for digital signal processing and gamma-ray tracking – of particular interest is the development of efficient and fast algorithms for signal decomposition and improved tracking programs; (3) alternative materials, with comparable resolution to germanium, but with significantly higher efficiency and relatively higher temperature operation (in order to overcome the costly and bulky requirement to cool germanium detectors to liquid nitrogen temperatures); (4) improvements and new developments in micropattern detectors – this would specifically include commercial and cost effective production of GEM foils and other types of micropattern structures, such as fine meshes used in Micromegas, as well as novel approaches that could provide high-resolution multidimensional readout; (5) advances in more conventional charged-particle tracking detector systems, such as drift chambers, pad chambers, time expansion chambers, and time projection chambers (areas of interest include improved gases or gas additives that resist aging, improve detector resolution, decrease flammability, and offer larger/more uniform drift velocity); (6) high-resolution, gas-filled, time-projection chambers employing CCD cameras to perform an optical readout; (7) gamma-ray detectors capable of making accurate measurements of high intensities ($>10^{11}$ /s) with a precision of 1-2 %, as well as economical gamma-ray beam-profile monitors; (8) for rare isotope beams, next-generation, high-spatial-resolution focal plane detectors for magnetic spectrographs and recoil separators, for use with heavy ions in the energy range from less than 1 MeV/u to over 100 MeV/u; (9) a bolometer with high-Z material (e.g. W, Ta, Pb) for gamma ray detection with segmentation, capable of handling 100 -1000 gamma rays per second; (10) detectors made of more conventional materials (silicon or scintillator), capable of reconstructing multiple-Compton gamma-ray scattering with mm resolution; and (11) advances in CCD technology, particularly in areas of fast parallel, low-power readout, and cross-talk control.

With respect to particle identification detectors, grant applications are sought for the development of: (1) inexpensive, large-area, high-quality Cherenkov materials; (2) inexpensive, position sensitive, large-sized photon detection devices for Cherenkov counters; (3) high resolution time-of-flight detectors; (4) affordable methods for the production of large volumes of xenon and krypton gas (which would contribute to the development of transition radiation detectors and also would have many applications in X-ray detectors); (5) very high resolution particle detectors or bolometers (including the required thermistors) based on semiconductor materials and cryogenic techniques; and (6) methods capable of distinguishing between gammas

and charged particles at very high accuracy, via the use of laser techniques and electromagnetic traps. Of particular interest are detector technologies capable of measuring energies of alpha particles and protons with less than 5 keV resolution, thereby allowing spectroscopy experiments using light charged particles to be performed in the same way as spectroscopy experiments using gammas.

Grant applications are also invited for innovative design of high-resolution particle separators needed for the spectrometer research program associated with a proposed next generation rare isotope beam facility. Interested parties should contact Dr. J. A. Nolen, Jr. at Argonne National Laboratory (nolen@anl.gov).

Lastly, grant applications are invited for innovative development related to the measurement of the electric dipole moment of the neutron, where polarized neutrons and polarized 3He atoms coexist in a bath of superfluid 4He at a temperature of ~500 millikelvin. Developments are sought for vacuum, detector, and optical components that can operate at cryogenic temperatures. Approaches of interest include the development of: (1) a wavelength shifter that converts extreme ultraviolet light (~80nm) to blue light, with a higher efficiency than tetraphenyl butedien; (2) coatings of non-magnetic high-resistance alloys deposited on a substrate (e.g., acrylic), which does not delaminate when cooled to cryogenic temperature; (3) superfluid-tight, high-voltage (400kV), cryogenic vacuum feedthrough with minimum leak current (<1nA); (4) high voltage (400kV) power supply with minimum ripple (Vpp < 1V)**; (**5) high quantum efficiency (~40%) photomultiplier tubes that can be used at liquid helium cryogenic temperatures; (6) electrically-conductive optically-clear plastics or coating; (7) a cryogenic piezo-electric actuator with inches of motion range and with a large closing force up to around 200 lbs; (8) highly sensitive room temperature magnetometers – e.g., improved fluxgate or fluxset magnetometers with sensitivity less than one microgauss (<100 pT) at one gauss field, with few mm profile. Interested parties should contact Dr. Martin Cooper at Los Alamos National Laboratory (mcooper@lanl.gov) for further specifications.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

b. Technology for Rare Particle Detection—Grant applications are sought for particle detectors and techniques that are capable of measuring very weak, rare event signals in the presence of significant backgrounds. Such detector technologies and analysis techniques are required in searches for rare events (such as double beta decay) and for applications in extending our knowledge of new nuclear isotopes produced at radioactive beam facilities. Rare decay and rare phenomenon detectors require large quantities of very clean materials, such as clean shielding materials and clean target materials. For example, neutrino detectors need very large quantities of ultra-clean water.

Grant applications are sought to develop: (1) ultra-low background techniques of contacting, supporting, cooling, cabling, and connecting high-density arrays of detectors – ultrapure materials must be used in order to keep the generated background rates as low as possible (goal is 1 micro-Becquerel per kg); (2) advanced detector cooling techniques and associated infrastructure (high-density signal cabling, signal and high voltage interconnects, vacuum feedthroughs, front-end amplifier FET assemblies) to assure ultra-low levels of radioactive contaminants; (3) measurement methods for the contaminant level of the ultra-clean materials; (4) novel methods capable of distinguishing between gammas and charged particles; and (5) methods by which the backgrounds to rare searches, such as those induced by cosmogenic neutrons, can be tagged, reduced, or removed entirely.

Grant applications also are sought for new technologies to produce large quantities of separated isotopes, such as kg quantities of Ge-76, Se-82, Te-130, Xe-136 and other materials, which are needed for rare particle and rare decay searches in nuclear physics research.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

c. Large Band Gap Semiconductors, New Bright Scintillators, Calorimeters, and Optical Elements— Grant applications are sought to develop new materials or advancements for photon detection. Of specific interest are: (1) large band gap semiconductors such as CdZnTe, HgI_2, AlSb, etc.; (2) bright, fast scintillator materials ($LaHA_3$:Ce, where HA=Halide) and scintillators with pulse-shape discrimination (PSD) (n/gamma and charged particle); (3) selenium based detectors (perhaps using GaSe, CdSe or ZnSe); (4) plastic scintillators, fibers, and wavelength shifters; (5) cryogenic scintillation detectors (LXe); (6) Cherenkov radiator materials with indices of refraction up to 1.10 or greater, and with good optical transparency; and (7) new and innovative calorimeter concepts, including new materials, higher packing densities, or innovative fiber and absorber packing schemes.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

d. Nuclear Targets and High-Radiation Environment Beam Transport Components—Grant applications are sought to develop specialized targets for the nuclear physics program, including: (1) polarized (with nuclear spins aligned) high-density gas or solid targets; (2) frozen-spin active (scintillating) targets; (3) windowless gas targets and supersonic jet targets for use with very low energy charged particle beams; (4) liquid, gaseous, and solid targets capable of high power dissipation when high intensity, low-emittance charged-particle beams are used; (5) high-power targets with fast release capabilities for the production of rare isotopes; and (6) thin (<few micro-g/cm^2), condensed-phase hydrogen targets that can be well localized (1mm in all directions).

Grant applications also are sought to develop the technologies and sub-systems for the targets required at high-power, advanced, exotic beam facilities that use heavy ion drivers for rare isotope production. These targets include those that would be used for heavy ion fragmentation, as well as those that would be used with high power light ion beams for the production of exotic isotopes by spallation reactions.

In addition, grant applications are sought to develop techniques for: (1) the production of ultra-thin films needed for targets, strippers, and detector windows – regarding a next generation rare isotope beam facility, there is a need for stripper foils or films (in the thickness range from a few micrograms per cm^2 to over 10 milligrams per cm^2) for use in the driver linac with very high power densities from uranium beams; and (2) the preparation of targets of radioisotopes, with half-lives in the hours range, to be used off-line in both neutron-induced and charged-particle-induced experiments.

Finally, grant applications are sought for techniques and strategies needed for ion beam transport in the high-radiation environment anticipated at a future rare isotope beam accelerator facility. Approaches of interest include: (1) simulations to characterize radiation doses to magnets and other components near the production targets and beam dumps; (2) development of appropriate containment for activated coolants such as liquid lithium and water; and (3) development of magnet design concepts that are consistent with the radiation dose, field, and aperture requirements set by optics calculations.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

References:

1. Bellwied, R., et al., "Development of Large Linear Silicon Drift Detectors for the STAR Experiment at RHIC," *Nuclear Instruments and Methods in Physics Research*, A377:387, 1996. (ISSN: 0168-9002)*

2. *Conceptual Design Report for the Solenoidal Tracker at the Relativistic Heavy Ion Collider (RHIC)*, Lawrence Berkeley National Laboratory, June 15, 1992. (Report No. LBL-PUB-5347) (NTIS Order No. DE92041174) (Abstract and ordering information available from National Technical Information Service

(NTIS). Telephone: 1-800-553-6847. Web site: http://www.ntis.gov/. Search by order number. Please note: Items that are unavailable via the Web site might be obtained by phoning NTIS.)

3. Deleplanque, M. A., et al., "GRETA: Utilizing New Concepts in Gamma Ray Detection," *Nuclear Instruments and Methods in Physics Research*, A430:292-310, 1999. (ISSN: 0168-9002)*

4. *Conceptual Design Report for the measurement of neutron electric dipole moment, nEDM,* Los Alamos National Laboratory, February 2007. (Full text available at: http://p25ext.lanl.gov/edm/pdf.unprotected/CDR(no_cvr)_Final.pdf)

5. Eisen, Y., et al., "CdTe and CdZnTe Gamma Ray Detectors for Medical and Industrial Imaging Systems," *Nuclear Instruments and Methods in Physics Research*, A428:158, 1999. (ISSN: 0168-9002)*

6. Grupen, C., Particle Detectors, New York: Cambridge University Press, 1996. (ISBN: 0-5215-52168)

7. Morrison, D. P., et al., "The PHENIX Experiment at RHIC," *Nuclear Instruments and Methods in Physics Research*, A638:565, 1998. (ISSN: 0375-9474)

8. Gatti, F., ed., *Proceedings of the Tenth International Workshop on Low Temperature Detectors, Genoa, Italy, July 7-11, 2003*, Nuclear Instruments and Methods in Physics Research, A520, 2004. (ISSN: 0168-9002)*

9. Vetter, K., et al., "Three-Dimensional Position Sensitivity in Two-Dimensionally Segmented HP-Ge Detectors," *Nuclear Instruments and Methods in Physics Research*, A452:223, 2000. (ISSN: 0168-9002)*

10. van Loef, E.V., et al., "Scintillation Properties of $LaBr_3:Ce^{3+}$ Crystals: Fast, Efficient and High-Energy-Resolution Scintillators," *Nuclear Instruments and Methods in Physics Research,* A486:254, 2002. (ISSN: 0168-9002)*

11. Andersen, T. C., et al., "Measurement of Radium Concentration in Water with Mn-coated Beads at the Sudbury Neutrino Observatory," *Nuclear Instruments and Methods in Physics Research*, A501:399, 2003. (ISSN: 0168-9002)*

12. Andersen, T. C., et al., "A Radium Assay Technique Using Hydrous Titanium Oxide Absorbant for the Sudbury Neutrino Observatory," *Nuclear Instruments and Methods in Physics Research*, A501:386, 2003. (ISSN: 0168-9002)*

13. *Historical Development of the Plans for CEBAF @ 12 GeV* Website, U.S. DOE Thomas Jefferson Accelerator Facility. (URL: http://www.jlab.org/12GeV/)

14. *eRHIC: The Electron-Ion-Collider at BNL* Website, U.S. DOE Brookhaven National Laboratory. (URL: http://www.phenix.bnl.gov/WWW/publish/abhay/Home_of_EIC/)

15. *RHIC: Relativistic Heavy Ion Collider* Website, U.S. DOE Brookhaven National Laboratory. (URL: http://www.bnl.gov/RHIC/)

16. Miyamoto, J., et al., "GEM Operation in Negative Ion Drift Gas Mixtures," *Nuclear Instruments and Methods in Physics Research*, A526:409, 2004. (ISSN: 0168-9002)*

17. Batignani, G., et al., eds., *Frontier Detectors for Frontier Physics: Proceedings of the 8th Pisa Meeting on Advanced Detectors, La Biodola, Isola dElba, Italy, May 25-31, 2003*, Nuclear Instruments and Methods in Physics Research, A518, 2004. (ISSN: 0168-9002)

18. *Proceedings of the 2003 RIA R&D Workshop, Bethesda, MD, August 26-28, 2003*. (Workshop Presentations available at: http://www.orau.org/ria/r&dworkshop/present.htm) (40-page formal report of Workshop available at: http://www.pubs.bnl.gov/documents/25894.pdf)

19. Arnaboldi, C., et al., "CUORE: A Cryogenic Underground Observatory for Rare Events," *Nuclear Instruments and Methods in Physics Research*, A518:775, 2004. (ISSN: 0168-9002)*

* Abstract and ordering information available at: http://sciencedirect.com. Search by title of article.

OFFICE OF ENVIRONMENTAL MANAGEMENT

38. DEACTIVATION AND DECOMMISSIONING OF FACILITIES AND SITE REMEDIATION IN THE DOE COMPLEX

Since the 1940s, numerous DOE buildings and facilities have handled toxic and radioactive materials. These facilities were used for chemical separations; component and weapons fabrication; fuel/target fabrication; reactor operations; enrichment operations; and mining, milling, and refining.

The DOE is responsible for the deactivation and decommissioning (D&D) of these facilities. Deactivation refers to ceasing facility operations and placing the facility in a safe and stable condition to prevent unacceptable exposure of people or the environment to radioactive and other hazardous materials until the facility can be decommissioned. Decommissioning is the process of decontaminating or removing contaminated material and equipment, including piping that is either in facilities or buried underground, to achieve the end state for the facility or site.

The DOE is also responsible for site remediation, which includes the cleanup of contaminated groundwater, sediments, and soils. Site remediation is usually performed under requirements of the Comprehensive Environmental Response, Comprehension and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA). In particular, new or improved technologies are needed to help with the remediation of mercury, which has been shown to contaminate soils, sediments, surface water, and groundwater in and around DOE sites.

Proposed technologies should reduce health and safety risks to workers and the environment during D&D or site remediation activities. Desired end states include complete removal and remediation of the facility, facility entombment, and release of the facility for either unrestricted or restricted use. **Grant applications are sought only in the following subtopics:**

a. Technologies to Improve Performance of D&D Operations—Many facilities throughout the DOE complex are contaminated with radionuclides, metals (including lead and mercury), asbestos, and organic compounds. Some of these facilities reside in a safe storage or surveillance and maintenance mode, until they can be scheduled for decontamination and demolition. These DOE sites also contain piping, both within buildings and buried underground. Some parts of this piping, which can be miles long, are contaminated with radionuclides, organics, and other hazardous materials. (In fact, some sites, such as Hanford, have hundreds of miles of pipes.) Grant applications are sought to develop technology to improve the characterization of contamination in the pipes, in order to determine the extent of the contamination present and its location within

the pipes, especially in buried or underground piping. Grant applications also are sought to develop improved deactivation, retrieval, size reduction, and stabilization, both for pipes and for any other part of D&D activity. Finally grant applications are sought for advanced remote and robotic methods for D&D. Proposed technologies/methodologies should demonstrate: (1) the potential for significant and measurable improvements in the areas of safety, environmental protection, and cost reduction, and (2) the promise of improving decommissioning planning and operations.

Questions - contact Justine Alchowiak (justine.alchowiak@em.doe.gov)

b. Characterizing, Monitoring and Remediating Mercury Contaminated Soils and Sediments at DOE Sites—Historically, releases of mercury have resulted in contamination of soil, groundwater, surface water, sediments and biota, posing difficult assessment and cleanup challenges at a number of DOE sites (including Oak Ridge, Hanford, and Savannah River). Grant applications are sought to develop new or improved technologies and techniques for: (1) identification and characterization of sources of mercury contamination, including determination of the physical and chemical forms of mercury present; (2) *in situ* treatment of mercury contamination; (3) application of enhanced attenuation and Monitored Natural Attenuation of mercury in the subsurface environment; (4) improvement of *ex situ* treatment of contaminated soils and water, in order to increase efficiency or reduce cost; (5) unobtrusive characterization of mercury contamination in the subsurface environment, particularly in areas that are difficult to access; and (6) cost-effective near-term and long-term monitoring of mercury contamination in soils and groundwater. Proposed remediation technologies should minimize any mobilization and/or release of mercury during its application.

Questions - contact Justine Alchowiak (justine.alchowiak@em.doe.gov)

References:

1. U.S. DOE, Office of Environmental Management Website. (URL: http://www.em.doe.gov/)

2. National Academy of Sciences/National Research Council, Research Opportunities for Deactivating and Decommissioning Department of Energy Facilities, National Academy Press, 2001. (ISBN-10: 0-3090-75955) (ISBN-13: 9-7803-09075-954) (Full text available at: http://www.nap.edu/catalog/10184.html)

3. U.S. DOE Savannah River Site Website. (URL: http://www.srs.gov)

4. Department of Energy Hanford Site Website, Richland [Washington] Operations Office, Office of River Protection. (URL: http://www.hanford.gov/)

5. Department of Energy Office of River Protection Website. (URL: http://www.hanford.gov/orp/)

6. U.S. Department of Energy Idaho Operations Office Website. (URL: http://www.id.doe.gov)

7. United States Department of Energy Oak Ridge Office Website. (URL: http://www.oakridge.doe.gov)

OFFICE OF ADVANCED SCIENTIFIC COMPUTING RESEARCH

39. NUMERICAL SOFTWARE MAINTENANCE

The Office of Advanced Scientific Computing Research has been fully or partially responsible for funding the research and development (R&D) of a wide range of robust, high-quality numerical algorithms for scientific computation. These algorithms contribute to the development of libraries such as EISPACK, LINPACK, LAPACK, ScaLAPACK, ARPACK, CLAWPACK, PETSc, TAO, CHOMBO, ebCHOMBO, SALSA, MPSALSA, LOCA, HYPRE, SuperLU, FronTier, and many others. However, a number of critical issues still must be resolved in order to ensure that the value of the software is maintained and that the large R&D investment is maximized.

Grant applications are sought only in the following subtopics.

a. Numerical Software Maintenance, Versioning, and Distribution—With the increased proliferation of software applications, there exists a need to ensure that an orderly and efficient mechanism exists for configuration control of software applications. Grant applications also are sought to: (1) develop new maintenance and distribution mechanisms to ensure that updated scientific libraries are subjected to validation and verification testing; (2) implement formal tracking mechanisms for bug reports, bug fixes, and update notification for a wide range of scientific algorithm libraries; (3) develop and maintain mechanisms for providing cost effective portability of scientific libraries across a wide range of computer architectures, from desktop systems to massively parallel leadership-class supercomputers; (4) develop and maintain high-quality user documentation for each component of scientific software, including advice on domains of applicability for each module; and (5) develop comprehensive email- or Web-based user support services for scientific libraries.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

b. Scaling Mathematical Tools and Libraries to Petascale—The DOE Office of Science has entered into the era of petascale computer science – marked by computers that operate a thousand times faster than today's teraflop computers. Petascale computing will enable the production of scientific simulation data about complex natural phenomena, on a scale not possible just a few years ago. In order to enable science at these speeds, existing mathematical libraries and tools must be scaled to take full advantage of petascale computing. Therefore, grant applications are sought for the scaling of existing mathematical libraries, solvers, and tools, so that they will work efficiently with petascale computers at the OOE National Leadership Facilities at Oak Ridge National Laboratory (ORNL), Argonne National Laboratory (ANL), and the National Energy Research Scientific Computing (NERSC) Center.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

References:

1 Anderson, E., et al., "LAPACK Users' Guide," 2nd ed., Philadelphia, PA: Society for Industrial and Applied Mathematics (SIAM), 1995. (ISBN: 0-8987-13455)

2 Dongarra, J. and Walker, D., "Software Libraries for Linear Algebra Computations on High Performance Computers," *SIAM Review*, 37: 151-180, 1995. (ISSN: 0036-1445)

3 Dongarra, J. J., et al., "Algorithm 679: A Set of Level 3 Basic Linear Algebra Subprograms," *ACM [Association for Computing] Transactions on Mathematical Software*, 16(1): 8-28, March 1990. (ISSN: 0098-3500)

4 Dongarra, J. J., et al., "Algorithm 656: An Extended Set of FORTRAN Basic Linear Algebra Subroutines," *ACM Transactions on Mathematical Software*, 14(1): 18-32, March 1988. (ISSN: 0098-3500)

5 Geist, A., et al., eds., PVM: Parallel Virtual Machine. A Users' Guide and Tutorial for Networked Parallel Computing, Cambridge, MA: MIT Press, 1994. (ISBN: 0-2625-71080)

6 Pollicini, A. A., Using Toolpack Software Tools, Kluwer Academic Publishers, 1989. (ISBN: 0-7923-00335)

7 Blackford, L. S., et al., The ScaLAPACK Users Guide, Philadelphia, PA: SIAM, 1997. (ISBN: 0-8987-13978)

8 Smith, B. T., et al., "Matrix Eigensystem Routines," EISPACK Guide Lecture Notes in Computer Science, 2nd ed., Vol. 6, Springer-Verlag, 1976. (ISBN: 0-3870-75461)

9 Lehoucq, R. B., et al., ARPACK Users Guide: Solution of Large-Scale Eigenvalue Problems with Implicitly Restarted Arnoldi Methods, Philadelphia, PA: SIAM, 1998. (ISBN: 0-8987-14079)

10 Balay, S., et al., "Efficient Management of Parallelism in Object Oriented Numerical Software Libraries," in Modern Software Tools in Scientific Computing, pp. 163-202, Birkhauser Press, 1997. (ISBN: 0-8176-39748)

11 Balay, S., et al., "PETSc Users Manual," Argonne National Laboratory, 2002. (Report No. ANL-95/11 - Rev. 2.1.6) (Full text available at: http://www-unix.mcs.anl.gov/petsc/petsc-2/snapshots/petsc-current/docs/manual.pdf)

12 Benson, S., et al., "TAO Users Manual," Technical Report, Argonne National Laboratory, August 2004. (Report No. ANL/MCS-TM-242-Revision 1.7) (Full text available at: http://www-unix.mcs.anl.gov/tao/docs/manual/manual.html)

13 Shadid, J., et al., "MPSalsa Version 1.5: A Finite Element Computer Program for Reacting Flow Problems: Part 1 – Theoretical Development," Technical Report, Sandia National Laboratories, 1998. (Report No. SAND98-2864) (Full text available at: http://www.osti.gov/bridge/servlets/purl/2641-t7isU8/webviewable/2641.PDF)

40. SCIENTIFIC VISUALIZATION AND DATA UNDERSTANDING

Scientific visualization and data management are critical enabling technologies for computational science research, providing scientists with the capability to extract scientific insights from data sets generated by simulations and experiments. The visualization systems that are sought must be attuned to the needs of domain scientists and must be integrated with important data management and domain-specific science. In addition, to be part of a useful investigatory scientific research environment, visualization systems and data analytics must be integrated with supporting computational science technologies such as petascale computing, data management and data storage/retrieval, I/O capabilities, and networking capabilities for remote visualization.

Grant applications are sought only in the following subtopics:

a. Scientific Visualization and Management—Scientific discoveries enabled by petascale computational sciences require advanced visualization systems to extract the scientific insights from data generated by simulation and experiments. With petascale computing and other experiments expected to generate several petabytes of unstructured multi-dimensional data sets per year, next-generation scientific visualization systems

will outstrip the performance of today's systems. Next-generation visualization and data analytics will need advances in collaborative data analysis and visualization, comparative visualization, distance visualization, and knowledge-assisted visualization. The requirements in each of these areaswill be discussed in turn:

- Collaborative Data Analysis and Visualization – Large-scale scientific projects are increasingly performed in distributed environments, with collaborators, data, and compute resources in remote locations. Efforts to mitigate the effects of this separation have not kept pace with the advance of technology. Grant applications are sought to develop: (1) technology to significantly enhance interaction between users, systems, and software, (2) an infrastructure that can enable both synchronous and asynchronous collaborative interactions between users in the context of doing science, and (3) communications capabilities that can create a sense of participation and knowledge sharing, along with novel display technologies such as 3D autostereo.

- Comparative Visualization – Research models, and even production-class codes, are often run as a set to produce an ensemble that provides a higher-confidence output than an individual model or code. Similarly, researchers validating models or experimental measurements, or performing parameter studies and sensitivity analyses, generate multiple instances of data sets, which need to be compared and/or analyzed as a set. Therefore, grant applications are sought to develop diagnostic comparison tools, using visual means that go beyond side-by-side studies.

- Distance Visualization – The ability for scientists to visualize, analyze, and understand their research results is key to effective science. Yet, these activities are significantly hampered by the fact that the scientists and the supercomputing resources they work on are located in geographically different locations. As we move to larger-scale computing, this problem will become more severe, because of the need to move even more data over network. Grant applications are sought to develop: (1) latency-tolerant techniques for delivering interactive visualization results to remote consumers using distributed and parallel computational platforms, (2) techniques for delivering visualization results that gracefully accommodate the wide variance in network capacity, and (3) techniques for resource- and condition-adaptive partitioning of the visualization pipeline to meet performance or capability targets.

- Knowledge-Assisted Visualization – Although it is assumed that existing visualization systems support knowledge discovery, in fact, they just present graphics. The problem is that they are not formally integrated with methods and tools that enable the capture of knowledge, represent that knowledge and its provenance, or manage and reuse the knowledge gained in support of subsequent visual exploration and discovery. As a result, current visualization systems are used to address knowledge implicitly rather than explicitly. Grant applications are sought for new techniques and tools to enable visualization systems to be used to obtain knowledge, especially when the cost of visualization is high or when the visualization work is collaborative in nature.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

b. Petabyte-Scale Data Transformation, Discovery, and Distribution—Science is increasingly becoming more and more data-intensive. In many large-scale scientific experiments and simulations, the data management challenge already exceeds the compute-challenge in terms of its required resources. The storage and distribution of scientific data on an unprecedented scale, for scientists in different geographical locations, is the limiting or enabling factor of scientific discovery in many large-scale data-intensive scientific endeavors involving distributed resources and research teams. Grant applications are sought to develop scalable tools to facilitate the transformation, discovery, and distribution of scientific data (unstructured data). Areas of interest include but are not limited to:

- **Managing archival data on disk farms.** Of particular interest are new techniques and tools to manage data on thousands of disks, in order to achieve fast access and reliability, and to optimize power consumption.

- **Common data models and access Application Program Interfaces (APIs) for parallel file systems.** Currently, different parallel files systems, such as GPFS, Lustre, and PVFS have different data models and APIs. Of particular interest are new, common data models for all such systems, so that they are interchangeable.

- **Storage systems that permit on-demand storage space allocation.** This need includes the specification of file system APIs for space reservation and space lifetime management. Of particular interest are new techniques and tools to add such functionality storage systems.

- **Data models and systems for scientific data.** Of particular interest are data models appropriate for scientific data, including multidimensional data and spatio-temporal data. Database systems that manage query processing for such models are also of interest.

- **Techniques for integration of multi-disciplinary scientific data.** Today's scientific applications include data from multiple disciplines, such as an ecological study that includes chemistry, biology, and earth science data. Of particular interest are new techniques for integrating such data for the purpose of common query and analysis.

Grant applications focusing on commercial database management extension are not of interest and will be declined.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

References:

1 Bunn, J. and Newman, H., "Data-Intensive Grids for High-Energy Physics," Grid Computing, Making the Global Infrastructure a Reality, Berman, Fox and Hey, eds., UK: Wiley, 2003. (ISBN: 0-4708-53190)

2 "Planning ASCR/Office of Science Data-Management Strategy," *Data Management Challenge Workshop Report*, 2004. (Full text available at: http://www-conf.slac.stanford.edu/dmw2004/docs/DM-strategy-final.doc)

3 Childs, H. and Miller, M., "Beyond Meat Grinders: An Analysis Framework Addressing the Scale and Complexity of Large Data Sets," Proceedings of SpringSim High Performance Computing Symposium (HPC 2006), Huntsville, AL, April 2-6, 2006, pp. 181-186, 2006. (Full text available at: http://graphics.idav.ucdavis.edu/publications/print_pub?pub_id=891)

4 "Visualization Group: Current Projects," Research Activities at Lawrence Berkeley National Laboratory Website. (URL: http://vis.lbl.gov/Research/)

5 "Scientific Visualization," Research Activities at Lawrence Livermore National Laboratory Website. (URL: http://www.llnl.gov/graphics/)

6 Visualization Research Activities at Pacific Northwest National Laboratory. (URL: http://www.pnl.gov/news/experts/visualization.stm)

41. HIGH PERFORMANCE NETWORKS

Advances in high performance network capabilities and distributed systems technologies are making it easier for large geographically dispersed teams to collaborate effectively. However, significant research questions must be addressed if co-laboratories are to achieve their potential, namely, by providing: (1) remote access to terascale computing resources and data archives; (2) remote users with an experience that approaches "being there;" and (3) remote visualization generated by analysis of large data sets and by simulation. Grant applications are sought to develop software tools and services to support coordinated and dynamic resource sharing in areas such as resource discovery, resource access, authentication, authorization to enable resource sharing and scientific collaborations.

Grant applications are sought only in the following subtopics:

a. High-Speed Network Provisioning Tools and Services—DOE operates a high-performance IP-based network called ESnet. ESnet interconnects science facilities, supercomputer centers, and data repositories, and also enables large scientific collaborations. The current ESnet backbone is based on Packet over SONET. In the future, it is anticipated that the ESnet core network will exploit advanced optical network technologies such as GMPLS and MPLS, in order to deliver end-to-end on-demand circuits and bandwidth. Therefore, grant applications are sought to develop advanced agile optical networks for ESnet. These end-to-end system-level technologies must be suitable for deployment and testing on the Ultra-Science Net (USnet), a DOE-funded optical network testbed operated by Oak Ridge National Laboratory. (USnet is used to develop, deploy, and test advanced optical network technologies for ESnet; further information on USnet can found at: http://www.csm.ornl.gov/ultranet/.) Specific areas of interest in agile optical networks include, but are not limited to: rs-GMPLS extensions with bandwidth reservation and scheduling; MPLS and rs-GMPLS security; inter-domain rs-GMPLS signaling; hybrid packet/circuit switched technologies; integration of QoS, MPLS, and rs-GMPLS, traffic engineering for rs-GMPLS-based networks; and end-to-end network monitoring tools and services. Grant applications must clearly outline how the proposed technology can be deployed and tested on the USnet testbed. Grant applications dealing with low level optical network components – such as optical cross-connect, optical amplifiers and signal processing, chip design and manufacturing, wireless network technologies, etc. – are beyond the scope of this topic and will be declined.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

b. High-Speed Network Security Systems—Office of Science R&D activities are conducted in an open but secure science environment. In this environment, the security systems deployed to protect cyber attacks must be carefully designed and deployed, so as to not hinder scientific discoveries. Grant applications are sought to develop intelligent and scalable cyber security systems that can operate at speeds up to 10 Gpbs and beyond. Proposed cyber security systems must be fast, highly robust, and transparent to end users. Technologies of interest include, but are not limited to: ultra-high-speed Intrusion Detection Systems (IDS), high-speed firewall systems, authentication systems for rs-GMPLS control Plane, VLANs security, and optical layer security.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

References:

1 Rao, N. S., et al., "Ultra Science Net: Network Testbed for Large-Scale Science Applications," *IEEE Communications Magazine*, 2005. (ISSN: 0163-6804) (Full text available at: http://www.csm.ornl.gov/ultranet/overview.pdf)

2 "Network Provisioning and Protocols for DOE Large-Science Applications," Report of DOE Workshop on Ultra High-Speed Transport Protocol and Dynamic Provisioning for Large-Scale Applications, Argonne, IL, August 10-11, 2003. (Full text available at: http://www.csm.ornl.gov/ghpn/wk2003.html)

3 "DOE Science Networking - Roadmap to 2008," 2003. (Report available at: http://www.es.net/hypertext/welcome/pr/Roadmap/)

4 "Energy Sciences Network," U.S. DOE Lawrence Berkeley National Laboratory Website. (URL: http://www.es.net/)

5 Rao, N. S., et al. "Experimental Results on Data Transfers over Dedicated Channels," First International Workshop on Provisioning and Transport for Hybrid Networks: PATHNETS, 2004. (Full text available at: http://www.broadnets.org/2004/workshop-papers/Pathnets/05_ExperimentalResultsonDataTransfers-NageswaraRao.pdf)

6 "The Hybrid Optical and Packet Infrastructure [HOPI] Project," Internet2 Website. (URL: http://networks.internet2.edu/hopi/)

7 "User Controlled Light Path Provisioning [UCLP]," University of Ottawa and Communications Research Center Website. (URL: http://www.uclp.ca/)

8 "High-Performance Networks for High-Impact Science," Report of the August 13-15, 2002 Workshop conducted by the Office of Science, U.S. Department of Energy. (Full text available at: www.doecollaboratory.org/meetings/hpnpw/finalreport/high-impact_science.pdf)

9 Veeraraghavan, M., et al., "CHEETAH: Circuit-Switched High-Speed End-to-End Transport Architecture," Proceedings of Outcome 2003, Dallas, TX, October 13-17, 2003. (Poster available at: http://www.csm.ornl.gov/workshops/DOE_SciDAC/040322-CHEETAH.pdf)

10 Veeraraghavan, M. and Zheng, X., "A Reconfigurable Ethernet/SONET Circuit Based Metro Network Architecture," *IEEE Journal on Selected Areas in Communication*, 22(8): 1406-1418, October 2004. (Full text available at: http://www.ece.virginia.edu/~mv/pdf-files/jsac2004-rescue.pdf)

42. SCALABLE SYSTEM SOFTWARE FOR PETASCALE COMPUTER SYSTEMS

High-performance computing (HPC) research in the Office of Science at the U.S. Department of Energy supports research that contributes to comprehensive, scalable, and robust computing to enable scientific discoveries. HPC currently supports research and development that focuses on petascale computing systems: computers operate 1000 times faster than today's large-scale systems. The primary areas of research include scalable system software, scientific visualization systems, data management tools, programming models, and related issues.

Grant applications are sought only in the following subtopics:

a. Petascale System Software—Emerging large-scale science endeavors increasingly call for extreme-scale supercomputing systems. These systems, which will exploit tens to hundreds of thousands of processors, will be based on a variety of challenging architectures, from distributed memory clusters of unprecedented scale to radically different innovative architectural concepts such as PIMs, FPGAs, and complex memory hierarchies. In turn, these architectures will require internal parallel I/O subsystems that comprise dedicated I/O nodes, each with processor, memory, and disks. Massively parallel processors (MPPs), encompassing from tens to thousands of processors, are emerging as a major architecture for high-performance computers. The new supercomputing systems will differ greatly in scale and complexity from today's systems, placing new and challenging demands on system software and related supporting hardware subsystems. Therefore, grant applications are sought to develop: (1) optical transceivers to improve CPU-to-CPU and CPU-to-memory bandwidth performance over copper based solutions; (2) operating system tools and support for the effective management of terascale systems and beyond; (3) effective tools for feature identification; (4) parallel and network I/O; (5) lightweight, scheduler communication mechanisms and queue management tools; and (6) FPGA algorithm accelerators, which maximize the performance of specific algorithms through a direct connection to the network infrastructure.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

b. Petascale File Systems—Global parallel file systems such as GPFS and Lustre are widely used in the Office of Science to manage file systems within major computer systems that have a few thousand processors. However, a balanced petascale computer may have 100,000 processors, which would require a bandwidth on the order of 1 Terabytes per second (TB/s). Yet, it is well understood that the bandwidth to storage devices is not keeping pace with computational trends, and that the gap will continue to widen in the future. Grant applications are sought to develop technology for overcoming the bandwidth issue with respect to petascale filing and storage. Approaches of interest include the development of: (1) scalable parallel file systems that explore the use of clustered metadata and metadata checksum/mirroring to handle up to one trillion files in a file system; (2) technology to address the scaling, performance, and/or stability of an existing global parallel file system; and (3) I/O disk and client services that will bind the global file systems to storage systems and petascale computing systems.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

c. Debugging and Performance Monitoring of Petascale Systems—Current supercomputing systems, which consist of thousands of nodes, cannot meet the demands of emerging high-performance scientific applications. As a result, a new generation of supercomputing systems, consisting of hundreds of thousands of nodes, is being proposed. However, these systems are likely to experience far more frequent failures than today's systems, and such failures must be tackled effectively. The parallel debugging solution used today, Total View, does not work for applications above 1,000 tasks, and only works on one near-HPC system beyond 1,000 nodes. The debugging of large-scale scientific applications with up to 100,000 interdependent parallel tasks will require alternative approaches with massive concurrency. Grant applications are sought to develop a new debugging paradigm for large systems with tens of thousands of processors. One possible approach involves coordinated check-pointing, a proposed technique to deal with failures in petascale computing systems – unlike existing check-pointing models, the proposed model takes into account failures during check-pointing and recovery, as well as correlated failures.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

d. Applied Computational Sciences Partnership—An integral part of the primary ASCR mission is to discover, develop, and deploy tools that enable analysis, modeling, simulation, and prediction of complex

phenomena important to the Department of Energy (DOE). Therefore, grant applications are sought to develop innovative algorithms that can exploit the emerging capabilities of petascale computing (and pave the way to exascale) to fully realize the potential to unravel complex scientific phenomena of interest to the DOE. Grant applications must: (1) focus on developing premier resources or intellectual property that leads to critical advances in a science area important to the DOE, including fusion simulation, subsurface modeling, accelerator science, and nanoscience; (2) be interdisciplinary, involving a three way partnerships between applied mathematicians, computer science researchers, and application scientists; (3) be led by computational scientists; (4) have clearly focused scientific goals; and (5) identify the specific tools, technology, or techniques that will be adapted.

Questions - contact George Seweryniak (seweryni@ascr.doe.gov)

References:

1 Aguilera, M. K., et al., "Failure Detection and Consensus in the Crash-Recovery Model," *Distributed Computing*, 13(2): 99-125, April 2000. (Summary available at: http://www.liafa.jussieu.fr/web9/manifsem/description_en.php?idcongres=129)

2 Butler, G., et al., "GUPFS: The Global Unified Parallel File System Project at NERSC," Proceedings of the 21st IEEE/12th NASA Goddard Conference on Mass Storage Systems and Technologies, pp. 361-371, April 2004. (Full text available at: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20040121020_2004117345.pdf)

3 Williams, E., et al., "The Characterization of Two Scientific Workloads Using the Cray X-Mp Performance Monitor," Proceedings of Supercomputing '90, pp. 142-152, IEEE, 1990. (ISBN: 0-89791-412-0) (Full text available at: http://portal.acm.org/citation.cfm?id=110382.110420)

4 Fagg, G. E., et al., "Scalable Fault Tolerant MPI: Extending the Recovery Algorithm," *Lecture Notes in Computer Science*, Volume 3666 – Recent Advances in Parallel Virtual Machine and Messaging Passing Interface Users' Group Meeting Euro PVMMPI 2005, pp 67-75, Springer Heidelberg, 2005. (ISSN: 0302-9743) (Full text available at: http://icl.cs.utk.edu/projectsfiles/rib/pubs/sftmpi-europvm-mpi-2005.pdf)

5 "National Leadership Computing Facility: A Partnership in Computational Sciences," U.S. DOE Oak Ridge National Laboratory Website. (URL: http://www.ccs.ornl.gov/nlcf/)

6 SciDAC (Scientific Discovery through Advanced Computing) Website. (URL: http://www.scidac.gov/app_areas.html)

7 SciDAC Review Website. (URL: www.scidacreview.org)

43. HIGH-PERFORMANCE MIDDLEWARE

Advances in high performance network capabilities and distributed systems technologies are making it easier for large geographically dispersed teams to collaborate effectively. However, significant research questions must be addressed if co-laboratories are to achieve their potential, namely, by providing: (1) remote access to terascale computing resources and data archives; (2) remote users with an experience that approaches "being there;" and (3) remote visualization generated by analysis of large data sets and by simulation. Grant applications are sought to develop software tools and services to support coordinated and dynamic resource

sharing in areas such as resource discovery, resource access, authentication, authorization to enable resource sharing and scientific collaborations.

Grant applications are sought only in the following subtopics:

a. Scientific Data Management and Understanding—Modern science is increasingly becoming a data-intensive activity, with experiments (in such science areas as high-energy and nuclear physics, climate modeling, computational biology, and fusion energy) estimated to generate petabyte scales of unstructured domain science data. Consequently, the importance of managing scientific data and information is recognized as being in the critical path of modern scientific endeavor. Accordingly, grant applications are sought to develop: (1) workflow solutions for unstructured data management technologies, in order to aid the construction and automation of scientific problem-solving processes; (2) meta-data and data description services to describe and track data within and across different communities; (3) efficient data access and query technologies to handle the organization of complex scientific data that is not based on simple relational tables, as used in commercial systems; (4) scalable data storage and distribution services and tools for data transmission (over switched optical links), data replication, and data discovery. (5) high-speed data storage and caching services to deal with high-performance data access, random I/O, and dynamic data storage and caching; and (6) data analysis services to enable next-generation scientific visualization, feature identification, and tracking. Commercial database systems and their variants dealing with structured data are beyond the scope of the subtopics and will be declined.

Questions - contact George Seweryniak (seweryni@ascr.doe.gov)

b. Scalable I/O Sub-Systems for Petascale Data Distribution—The rapid movement of data into and out of petascale systems is critical to achieving high performance. At the petascale level, this involves many hundreds to thousands of I/O channels from compute nodes (connected by a high-speed switch fabric) to file servers. Although switch performance is evolving rapidly, high performance communications switches are not yet optimized for the kinds of loads that petascale computers place on them. In petascale applications, each switch port has a very high duty cycle, so non-blocking architectures are preferred. Also, the data flow is very directional – i.e., a set of ports "A" always exchanges data with a disjoint set "B," and "A" ports do not exchange data with other "A" ports. A related problem at the petascale level is traffic management: for example, more ("A") ports typically are connected to compute nodes than to file servers ("B" ports); thus, when data is dumped from the petaflops system to files, the data backs up on the input side of the switch. To address these problems, grant applications are sought to develop optimized switch hardware and software for petascale I/O applications.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

c. Scalable and Secure Services for Middleware Technologies Related to Large-Scale Scientific Collaborations—The implementation of worldwide high speed interconnected networks, combined with a distributed workforce that needs to collaborate, requires a corresponding upgrade in middleware services. Therefore, grant applications are sought for the development and maintenance of scalable middleware technologies that will: (1) enable universal, ubiquitous, easy access to remote computing resources and scientific instruments; (2) facilitate collaboration among distributed science teams; and (3) enable a new generation of distributed high-end applications of interest to the DOE.
Areas of interest include but are not limited to: (1) long-term enhancement and maintenance of Access Grid facilities and grid software, (2) scalable scientific workflow for large-scale science projects, (3) scalable authentication/authorization services, (4) deployable LAN and WAN QoS services, (5) wide-area distributed

data management, (6) efficient multicast capabilities, (7) automatic resource discovery protocols, (8) remote data access services, and (9) network-attached memory and storage systems.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

References:

1 Global Grid Forum Website. (URL: http://www.ggf.org/)

2 "High-Performance Networks for High-Impact Science," Report of the High-Performance Network Planning Workshop, August 13-15, 2002, U.S. DOE Office of Science, 2002. (Full text available at: www.doecollaboratory.org/meetings/hpnpw/finalreport/high-impact_science.pdf)

3 Foster, I., et al., "Grid Services for Distributed Systems Integration," *IEEE Computer*, 35(6): 37-46, June 2002. (ISSN: 0018-9162)

4 "DOE Science Networking - Roadmap to 2008," Final Report, 2003. (Full text available at: http://www.es.net/hypertext/welcome/pr/Roadmap/)

5 "The Office of Science Data-Management Challenge," Final Report of a series of U.S. DOE Data-Management Workshops held March-May 2004. (Full text available at: www.sc.doe.gov/ascr/ProgramDocuments/Final-report-v26.pdf)

6 Foster, I., and Kesselman, C., eds., "Grid 2: Blueprint for a New Computing Infrastructure," Morgan Kaufmann, 2004. (ISBN: 1-5586-09334)

OFFICE OF NULCEAR NONPROLIFERATION

44. REMOTE SENSING

The DOE/NNSA Office of Nonproliferation Research & Development (NA-22) sponsors the development of enabling technologies for identification of activities and connections associated with proliferation of weapons of mass destruction. Research areas include development of detectors, advanced optical systems, image and signal processing algorithms, and advanced information technologies.

Grant applications are sought only in the following subtopics.

a. Polarimetry in Remote Sensing Applications—One fundamental property of light is polarization. The processes of reflection, transmission, emission, and scattering all alter the polarization state of light. Thus, the measurement of the polarization state of light, or polarimetry, can tell us much about the process that the light went through to get to that state. Grant applications are sought to develop hardware and algorithms for detection and analysis of polarized light in remote sensing applications. The goal is to determine if polarization could add significant information to remote sensing techniques, including improvement in signal-to-noise, discrimination between man-made and natural objects, 'seeing' into shadows or through canopies, and object characterization (which relies on different textures and surface properties behaving differently). Of particular interest is the development of field-portable hardware that can make these measurements and algorithms that enable high confidence material discrimination.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

b. Tunable Imaging Filters—Electronically tunable optical filters enable color or multispectral imaging with no moving parts. For some applications, current filters do not provide sufficiently fast transition times between color states (e.g., currently available liquid crystal tunable filters typically respond in tens of milliseconds). Therefore, grant applications are sought for high speed tunable imaging filters with high throughput (greater than 40%), large spatial format (greater than 30 mm in clear aperture), and fast response time (less than a few milliseconds). Of interest are both broad-band (e.g. R/G/B) and narrow (less than 10 nm) spectral band filters from the UV to short-wavelength IR (i.e., from ~350 nm to 2000 nm, but not necessarily in one filter). Both liquid crystal and other relevant technologies are of interest.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

c. Information Integration for Nonproliferation Information—Grant applications are sought for the development of information integration technologies that combine disparate sensor data for defendable nonproliferation decision making. Grant applications also are sought to exploit physics-based performance models of the entire sensing process. Areas of interest include: (1) new concepts and techniques for extracting information from sensor data and other sources for detection, measurement, classification, and data-sensor-information fusion; (2) modeling the generation of observable signals from proliferation signatures; (3) clutter discrimination and rejection; (4) signal propagation through and distortion by the environment; (5) signal interaction with the sensor; (6) sensor noise characteristics, and (7) processing the resulting measurements at a level of sufficient realism to make reliable assessments of sensor performance.

For example, one possible project could involve the integration of community-standard chemical libraries into MODTRAN, in order to improve the capability for modeling chemical plumes in MWIR/LWIR. Such an effort would include generating band model parameters for the additional gases, modifying to MODTRAN to allow the arbitrary layering of these gases into the atmospheric description; and detailing the process for including the additional gases.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

References:

1 Goldstein, D. "Polarized Light, 2nd Edition, Revised and Expanded" Marcel Dekker, New York, 2003. (ISBN-10: 082474053X) (ISBN-13: 978-0824740535)

2 Jones, D. G., Goldstein, D. H., and Spaulding, J. C., "Reflective and Polarimetric Characteristics of Urban Materials," Proc. SPIE, Vol. 6240, Polarization: Measurement, Analysis, and Remote Sensing VII, April 2006. (Full text available at: http://spiedl.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=PSISDG006240000000162400A000001&idtype=cvips&gifs=yes)

45. RADIATION DETECTION

The DOE/NNSA Office of Nonproliferation Research and Development sponsors advanced concepts investigation to develop new radiation detection materials. The following topics are intended to move beyond

the largely empirical approach historically applied to the discovery and understanding of detector materials performance, and their growth, to a more fundamental and first-principles approach.

Grant applications are sought only in the following subtopics.

a. Detector Materials—Recent research has identified pathways to the development of lanthanide halide (especially, $LaBr_3$) crystals, which offer the potential for excellent spectroscopic quality, including bulk energy resolution less than 3% (Full Width at Half Maximum (FWHM) at 662keV). This level of performance would enable detection scenarios that require reliable radioisotope identification with room temperature materials. Therefore, grant applications are sought for research and development to address growth issues involving this material, leading to reliable, high yield, rapid, and large volume growth of $LaBr_3$. Phase I projects should demonstrate a clear path to improving existing growth techniques, so that large single crystals (up to and exceeding 300 cm3) of $LaBr_3$ can be produced at high yield. Phase I also should demonstrate the potential for spectroscopic quality (at or less than 3% FWHM at 0.662 MeV) and cost reduction (by a factor of 10 over current fabrication costs). Phase II should involve the demonstration of a fabrication process that not only produces material with the aforementioned characteristics, but also produces material that is largely free from the growth problems (especially cracking) that limit current yield. Awardees will be provided an opportunity to collaborate with the DOE national laboratories working in this area. Ultimately, this subtopic seeks to promote the U.S. industrial capacity to produce large volume, spectroscopic quality radiation detector scintillator materials.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

b. Detector Cooling—Grant applications are sought to develop alternative cooling technologies (other then Stirling engine based designs) for gamma ray detectors, which are typically cooled with liquid nitrogen. In particular, approaches should focus on improving the state-of-the-art for the cooling large HPGe crystals used in field conditions. Proposed designs must support remote operation and control, and provide a capability for unattended operation of at least six months duration.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

c. Advanced Radiation Transport Methods for Scenario Analysis—At the present time, the development of methods to calculate neutron and gamma fields is aimed primarily at such applications as nuclear power reactors. However, these calculations also are needed in radiation detection scenarios for national security applications, which present unique challenges in terms of simulation and modeling. Therefore, grant applications are sought to develop efficient methods to accurately calculate neutron and gamma-ray fields in the radiation transport community. Approaches of interest should attempt to glean methods from the larger transport community and apply them to radiation detection scenarios. Potential areas of inquiry include deterministic detector response calculations, ray-effect mitigation techniques for radiation detector problems, and truly hybrid-field calculations (e.g., intertwined deterministic and Monte Carlo methods). The end result should be significantly faster computations for NNSA's time-critical analyses, including emergency response.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

d. Radiation Transport Interfaces—In current research programs to develop radiation detection instruments, simplifying assumptions are frequently made in estimating the resolutions and efficiencies attainable by neutron and gamma-ray instruments. These assumptions tend to ignore scattering from materials around both the source and the detector, and also ignore the attenuation and scattering that occurs along the path between them.[1]

Monte Carlo programs such as MCNP[2], GEANT[3] and DORT[4] are capable of realistically modeling such problems, but the technical details of setting up, running, and interpreting the required simulations are beyond the ability of all but the most expert researchers. Although some laboratory[1] and commercial[5] packages are available to automate these tasks, none has been widely used and accepted. Therefore, grant applications are sought to develop user-friendly interfaces for the simulation programs that are employed for the study of radiation transport in source and detector problems. Grant applications should demonstrate an in-depth understanding of both the transport physics and likely real-world applications, which, in turn, will require careful specification of the constraints and range of validity. Ultimately, an interface that allows simple geometries to be modeled by moderately knowledgeable users would benefit detector programs across a number of agencies (NA-22, DHS, DNDO, and DTRA).

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

References:

1 "Radiation Transport for Detection," Pacific Northwest National Laboratory. (URL: http://modsim.pnl.gov/applications/security.stm)

2 Monte Carlo N-Particle Transport Code System. (URL: http://mcnp-green.lanl.gov/)

3 "GEANT4," (URL: http://geant4.web.cern.ch/geant4/)

4 DORT (Discrete Ordinates Radiation Transport Code) (URL: http://www.ornl.gov/sci/radiation_transport_criticality/codes.shtml)

5 "MORITZ Geometry Tool," White Rock Science, (URL: http://www.whiterockscience.com/moritz.html)

46. SEISMIC DETECTION

The DOE/NNSA Office of Nonproliferation Research and Development seeks development of technologies to improve monitoring of nuclear detonations. Although the specific technologies are sought to address challenges in economically employing seismic detection systems for nuclear treaty monitoring, it is expected that these technologies also would benefit other geophysical applications.

Grant applications are sought only in the following subtopics.

a. Miniaturized Seismometers—Grant applications are sought to develop very small, low power, low noise, short-period seismometers. Ideally, total sensor size should be less than 1 cubic inch; power consumption should be below 100 mW for a basic analog sensor, or below 500 mW for a sensor with digital output; and sensor self noise should be below the USGS Low Earth Noise Model (e.g., approximately 0.5 ng/sqrt(Hz) for an accelerometer), with dynamic range at least 120 dB over a frequency band of 0.2 to 40 Hz. Preference will be given to designs that: (1) simultaneously minimize size, power, and sensor noise; and (2) provide three-axis sensors, or single axis sensors that can be arranged as a three-axis sensor. Sensors should be designed for easy integration into various deployment packages, and should be rugged and robust for ease of handling during deployment. It is anticipated that extreme miniaturization or micro-electromechanical system (MEMS) technologies will be required.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

b. Digitization of Hardcopy Seismograms—Seismograms were originally recorded on paper or film of various sizes. Sometimes, critical information exists on microfilms of seismograms that were originally recorded on paper. Although the paper or microfilm provides an archival copy of the original seismogram, they are not usable for further analysis. Yet, these data are essential as baseline information important to the detection of nuclear detonations. To obtain digital seismograms that can be further analyzed, the digital traces must be extracted from the image files. Therefore, grant applications are sought to develop an automated system for producing digital traces from optically scanned digital images of seismograms. These scans are at differing optical resolutions appropriate for the dimensions of the original seismograms. Digital seismic traces should be output in one of the commonly-used seismic data formats: SEED (Standard for the Exchange of Earthquake Data; http://www.iris.edu/manuals/SEEDManual_V2.4.pdf), SAC (Seismic Analysis Code; http://www.llnl.gov/sac), or CSS (Center for Seismic Studies). In addition, the automated system must be capable of:

- Recognizing and following the seismic traces in image files. These are being scanned at 3200 dpi (dots-per-inch) resolution as gray-scale images (see "Project Archives" at http://www.iris.edu/seismo/projects). Some image files have traces that were originally written on a single piece of paper wrapped around a cylindrical drum. Other files have traces from several stations written along strips of film (such as 16 mm or 70 mm films). The image files may have traces from several types of seismic instruments, such as "short period" instruments (with frequencies between about 0.2 Hz and 10 Hz) or "long period" instruments (with wave periods between about 5 seconds and a few hundred seconds). Digital output traces should be sampled at uniform sampling rates appropriate for each type of instrument. Amplitude resolution of the samples should be adequate to capture a faithful replica of the original traces; presumably in 12-bit or 16-bit digital formats.

- Following traces that overlap adjacent traces, as well as traces whose amplitude was so large that they are clipped by having gone off the paper or film. The system does not need to capture the dynamic range corresponding to the full excursion of off-scale traces; however, an ability to perform extrapolations of such excursions would be desirable. An extreme example of trace overlap and trace clipping can be seen in seismograms of the 1964 Alaska earthquake (http://www.iris.edu/seismo/quakes/1964alaska/pdf; for example SCP LPZ). Although recordings of nuclear explosions and smaller earthquakes have less extreme ground motions, they still may suffer from trace overlap or off-scale traces.

- Correcting the artifacts that result from using a pen to write traces on some seismograms. Pen systems used a mechanical suspension that was generally either curvilinear or rectilinear. These pen suspensions may have produced significant distortion, especially if the pen was not "centered" properly. The system must be able to remove this distortion.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

References:

1 Nuclear Explosion Monitoring Research and Engineering Program Strategic Plan, National Nuclear Security Administration, September 2003. (Document No. DOE/NNSA/NA-22-NEMRE-2003) (Full text available at https://www.nemre.nnsa.doe.gov/cgi-bin/prod/nemre/index.cgi?Page=Strategic+Plan)

2 U.S. National Data Center, Air Force Technical Applications Center, http://www.tt.aftac.gov/toppage.html

3 Annual Research Review Proceedings for Ground-Based Nuclear Explosion Monitoring Research and Engineering, sponsored by the National Nuclear Security Administration and the Air Force Research Laboratory. (Available at: https://www.nemre.nnsa.doe.gov/cgi-bin/prod/researchreview/index.cgi?Page=Proceedings)

OFFICE OF HIGH ENERGY PHYSICS

47. HIGH ENERGY PHYSICS DATA ACQUISITION AND PROCESSING

The DOE supports the development of advanced electronics and computational technologies for the recording, processing, storage, distribution, and analysis of experimental data that is essential to experiments and particle accelerators used for High Energy Physics (HEP) research. Areas of present interest include event triggering, data acquisition, scalable clustered computer systems, distributed collaborative infrastructure, distributed data management and analysis frameworks, and distributed software development useful to HEP experiments and particle accelerators. Grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities.

Although particle physics detector instrumentation, data processing and analysis, and software development typically occur in large collaborative efforts at national particle accelerator centers, there are efforts where small businesses can make innovative and creative contributions to further development of the required advanced technologies. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. On-line directories of appropriate researchers are available by institution at http://www.hep.net/sites/directories.htlml.

Grant applications are sought only in the following subtopics:

a. High-Speed Electronic Instrumentation—Grant applications are sought to develop components, electronics, systems, and instrumentation modules as follows:

(1) Special purpose chips and devices are sought for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, pico-second-resolution time-to-digital converters, controllers, and communications interface devices.

(2) Circuits and systems are sought for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, pixilated imaging sensors, particle calorimeters, and Cerenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters (>300 MHz), and time-to-amplitude converters. Compatibility with one of the widely used module interconnection standards (e.g., VMEbus, PCIExpress, or high speed serial interfaces) is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

(3) Advanced, high speed logic arrays and microprocessor systems are sought for fast event identification, event trigger generation, and data processing with very high throughput capability. Such systems should be compatible with or implemented in one of the widely used module interconnection standards (e.g., VMEbus, PCIExpress, or high speed serial interfaces).

(4) Novel data acquisition components are needed for the readout and high-rate transmission of collected data. Therefore, grant applications are sought for the innovative use of fiber optic links and/or commodity high-bandwidth networks in data transmission between particle detectors and data recording or control systems. Approaches of interest should demonstrate technologies that feature one or more of

the following characteristics: low noise, radiation tolerance, low power consumption, high packing density, and the ability to handle a large number of channels at very high rates.

(5) Much of the electronics instrumentation in use in HEP is packaged in one of the international module inter-connection standards (e.g., VMEbus, PCIExpress, or high speed serial interfaces). Therefore, grant applications are sought for modules that will provide capabilities not previously available; for substantial performance enhancement to existing types of modules; and for components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, interconnection systems, communication modules and systems, and disk-drive interface modules.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

b. Large Scale Analysis Computer Systems—The Office of High Energy physics seeks grant applications to develop:

(1) computer system components and supporting software enabling cost-effective and reliable use of petabyte-scale storage networks, especially for magnetic disks, optical disks, and magnetic tapes;
(2) computer system components and supporting software enabling the use of transport protocols in a more efficient manner over local and wide area networks;
(3) improvements to the reliability of cybersecurity systems protecting distributed storage systems; and/or
(4) improvements to the reliability and performance of wide area networks.

Proposed efforts must address identified computing problems related to diverse, large scale computing systems that support particle physics data processing and analysis.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

c. Computational Methods and Infrastructure for Petascale Physics—The international nature of HEP experiments and their large computing resource requirements drive the current HEP paradigm of handling and analyzing experimental data in a highly distributed fashion. By aggregating world-wide computing resources from HEP and other disciplines, initiatives like the Open Science Grid [20] aim to make idle computing resources available to all participating disciplines. Grant applications are sought to support of the design, implementation, and operation of distributed computing systems comprising many distributed Teraflops of CPU power and distributed petabytes of data. Areas of current interest include middleware development for grid-enabled systems, distributed data management and analysis frameworks, distributed system configuration tools, monitoring and accounting tools, and security assurance tools for a distributed environment.
In addition, advanced computational tools and software are needed to strengthen the ability of dispersed particle physics researchers to collaborate and to address problems related to the acquisition, handling, storage, analysis, and visualization of large datasets by these distributed collaborations. Grant applications are sought to develop:

(1) client-server frameworks and Web tools for creating collaborative environments, facilitating remote participation of detector experts at the data collection stage, and/or allowing collaborators real-time two-way participation in remote meetings;
(2) software project management tools;
(3) computer system components and supporting software incorporating the use of Quality of Service features generally available in wide area networks;
(4) portable systems to hold very large collections of data of the type created in connection with the operation of very large detectors, along with data management tools;
(5) visualization and software environments appropriate for physics analysis;
(6) software to support data systems distributed over a wide area network;

(7) framework, interconnects, and other peripherals which allow the use and orderly aggregation of commodity computers and computer peripherals at larger than normal scales, or at higher performance levels than usual;
(8) software development tools for the production of computer software to meet identified problems related to distributed, large-scale software development, configuration management, and data analysis – approaches of interest include distributed portable testing and Computer Aided Software Engineering, such as configuration management tools for a portable, distributed environment;
(9) web tools for remote data selection ("skimming"); and
(10) algorithms and software tools for pattern recognition and optimization of data analysis.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

d. **Simulation and Modeling Techniques and Systems—**Grant applications are sought to develop advanced computing tools and software for high energy physics simulation and modeling. Topics of interest include simulation and modeling algorithms for high energy physics processes, particle detectors, and theoretical calculations. Grant applications also are sought in areas of simulation support – such as frameworks for the management, configuration, custody, and dissemination of simulation and modeling data – in order to enable sharing by multiple experiments and theory research groups.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

References:

1 "ATLAS Collaboration, ATLAS: Technical Proposal for a General-Purpose pp Experiment at the Large Hadron Collider," CERN, Geneva: CERN [European Laboratory for Particle Physics], December 1994. (Document No. CERN/LHCC/94-43, available at: http://atlas.web.cern.ch/Atlas/TP/tp.html).

2 "ATLAS HLT, DAQ, and DCS Technical Design Report," CERN, October 2, 2003. (Document No. CERN/LHCC/2003-022) (Available at: http://atlas-proj-hltdaqdcs-tdr.web.cern.ch/)

3 Bromley, D. A., "Evolution and Use of Nuclear Detectors and Systems," *Nuclear Instruments and Methods in Physics Research,* Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 162(1-3, pt. I): 1-8, 1979. (ISSN: 0168-9002)

4 "Documents Relating to CMS Software and Computing," CERN Website. (URL: http://cmsdoc.cern.ch/cms/software/reviews/papers.html)

5 Duggan, J. L. and Morgan, I. L., eds., Application of Accelerators in Research and Industry: Proceedings of the 14th International Conference, Denton, TX, November 6-9, 1996, 2 Vols., New York: American Institute of Physics, May 1997. (AIP Conference Proceedings No. 392) (ISBN: 1-5639-66522) (For ordering information, see: American Institute of Physics Conference Proceedings sub-series: *Accelerators, Beams, Instrumentation* at: http://proceedings.aip.org/proceedings/accelerators.jsp)

6 "Computer Applications in Nuclear and Plasma Science," Conferences on Real-Time Computer Applications in Nuclear, Particle, and Plasma Physics, IEEE-sponsored Website. (URL: http://ewh.ieee.org/soc/nps/CANPS.htm)

7 Kleinknecht, K., Detectors for Particle Radiation, Cambridge, MA: Cambridge University Press, 1986. (ISBN: 0-5213-04245)

8 Perkins, D. H., An Introduction to High Energy Physics, Reading, MA: Addison-Wesley, 1982. (ISBN: 0-2010-57573)

9 "PCI Express: Performance Scalability for the Next Decade," PCI-SIG Website. (URL: http://www.pcisig.com/specifications/pciexpress)

10 Regler, M., et al., "Data Analysis Techniques in High Energy Physics Experiments," Cambridge, MA: Cambridge University Press, 2000. (ISBN: 0-5216-32196)

11 "SciDAC:HENP" (Scientific Discovery Through Advanced Computing Programs in High Energy and Nuclear Physics), U.S. DOE Website. (URL: http://www.scidac.org/henp.html)

12 "DOE UltraScience Net: Experimental Ultra-Scale Network Research Testbed [Ultranet] for Large-Scale Science," U.S. DOE Website. (URL: http://www.csm.ornl.gov/ultranet/)

13 "Protocols for Fast Long Distance Networks," PFLDnet 2004: Second International Workshop on Protocols for Fast Long-Distance Networks at: http://www-didc.lbl.gov/PFLDnet2004/ and PFLDnet 2005: Third International Workshop on Protocols for Fast Long-Distance Networks at: http://www.ens-lyon.fr/LIP/RESO/pfldnet2005/.

14 Lattice QCD Executive Committee, "Computational Infrastructure for Lattice Gauge Theory: a Strategic Plan," U.S. DOE, April 4, 2002. (Full text available at: http://www.lqcd.org/scidac/strategic-plan-04-04.pdf)

15 International Linear Collider Communication Website, International Linear Collider Communication Group. (URL: http://www.interactions.org/linearcollider/)

16 "GGF Document Series," Global Grid Forum published documents. (URL: http://sourceforge.net/projects/ggf)

17 "Statistical Problems in Particle Physics, Astrophysics, and Cosmology Workshop Series" (See '05 Workshop Recommended Reading list: http://www.physics.ox.ac.uk/phystat05/reading.htm)

18 "CHEP'04 Interlaken [Computing in High Energy Physics Conference]," Interlaken Switzerland, Sept. 27-Oct.4, 2004, Website. (Website, including Conference papers at: http://chep2004.web.cern.ch/chep2004/)

19 Open Science Grid Website. (URL: http://opensciencegrid.org)

48. ACCELERATOR TECHNOLOGY FOR THE INTERNATIONAL LINEAR COLLIDER

The DOE High Energy Physics (HEP) program supports research and development for the International Linear Collider (ILC), a 500 GeV superconducting linear electron-positron collider that will probe the energy frontier with unprecedented precision. Advanced R&D needed for this program includes the development of 1.3 GHz superconducting radiofrequency (SRF) systems, beam instrumentation and feedback systems, magnet and fast kicker technology, as well as polarized radiofrequency (RF) photocathode sources. Relevance to the ILC must be explicitly described.

Grant applications are sought only in the following subtopics:

a. Superconducting Radiofrequency Systems—Research is needed in a variety of superconducting RF areas to support the development of the ILC. Accordingly, grant applications are sought:

(1) to develop high gradient, 1.3 GHz superconducting RF cavities, with application to the accelerating structures needed for the ILC. Multi-cell cavities, with accelerating gradients greater than 35 MV/m and *Q*-factors greater than $5x10^9$, are of particular interest. Priority areas of research focus include new cavity geometries, improved control of field emission, and suppression of high-field *Q*-slope. Of particular interest are research areas that provide the promise of significant results in the next few years and techniques that are suitable for automation and industrialization.

(2) for technology to support the development of fundamental power couplers and tuners for 1.3 GHz SRF cavities. Areas of interest include improvements to current coupler design (resulting in reduced conditioning time, reduced cost, and improved reliability); new tuner designs and concepts for both fast and slow tuning; and inexpensive, broad-band, 2K microwave absorbing material with repeatable electrical properties for high order mode (HOM) damping and resonance suppression.

(3) to develop high efficiency 1.3 GHz modulators and klystrons, capable of operation at peak power levels on the order of 10 MW, with a pulse width of 1-3 ms, at a repetition rate of 5-10 Hz. The modulator efficiency should be greater than 75%, and the klystron efficiency should be greater than 65%. Of greatest interest are modulator designs with a small physical footprint, a high reliability, and the capability to deliver high voltage pulses suitable for direct coupling to the klystron. Grant applications also are sought to develop power distribution systems suitable for the transport of L-band microwave power at the level of 10 MW (peak).

(4) to develop digital, low-level RF (LLRF) systems to control the phase and amplitude of SRF cavities operating at 1.3 GHz, with loaded *Q*-values in the range of 10^6. Of particular interest are systems capable of phase control at the level 0.5^o or better, and amplitude control at the level of 0.1% or better. Advanced LLRF systems that can perform vector sum control on ILC cryomodules, thus allowing each cavity to be run at its full potential, are also of interest.

(5) to develop SRF cavity processing technology to clean and improve the smoothness of the surface of multi-cell niobium (Nb) cavities. Priority approaches include: innovative chemical and electropolishing routes, especially those that reduce or eliminate the dependence on hydrofluoric acid; in-line diagnoses of process acids for ion content and dissolved metal; alternative routes such as tumbling, plasma cleaning, or ion bombardment; quality assurance, control, and testing technologies; and advanced cleaning and handling techniques to eliminate particulate contamination as a source of field emission in the cavities. Proposed processing technologies should be able to demonstrate an improvement in the accelerating gradient of the cavities, compared to present baseline techniques, at an equivalent or reduced cost of implementation.

(6) for research and development leading to the design and fabrication of ILC cryomodules for 1.3 GHz superconducting cavity strings. Each ILC cryomodule contains several 1.3 GHz cavities and couplers in its He vessels, quadrupoles, tuners, and 2K helium distribution system. Therefore, improvements in cryomodule design and fabrication, which result in lower costs, are of particular interest.

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

(8) to develop instrumentation that can be used to monitor x-rays caused by electron field emission in SRF cavities. Proposed systems should support mapping of radiation from ILC-type cavities during testing in vertical and horizontal test dewars. Sensors must be operable in liquid Helium at temperatures down to ~1.5 K. The objective is to determine the location(s) of the field emitters. Tomographic techniques may be applicable.

(9) to develop technologies to facilitate the installation, support, and alignment of very large accelerator beam line lattice elements.

Questions – contact LK Len (lk.len@science.doe.gov)

b. Beam Instrumentation and Feedback Systems—Instrumentation and feedback systems are needed to support the development of the ILC. Accordingly, grant applications are sought to develop:

(1) fast transverse feedback systems, appropriate for controlling vertical beam jitter at the 0.1 sigma level, in linear colliders with long bunch trains (on the order of 1 ms). Areas of particular interest include systems with bandwidth sufficient to control single bunches within a train (with a bunch separation of order 100 ns), and systems that can operate on a train-by-train basis (with a train repetition period of order 5 Hz). System design should be based on the bunch parameters of the ILC.*

(2) large aperture (> 70 mm diameter) linac beam position monitoring systems, capable of single-bunch position resolution of 1 μm (rms) or better. High precision beam position monitors for the damping rings and beam delivery system are also of interest. The system design must be relevant for the bunch parameters of the ILC.*

(3) high resolution beam profile monitoring systems capable of measuring the emittance of a high energy electron/positron beam, with the bunch parameters of the ILC.* The emittance should be measured with an accuracy of 10% or better.

Questions – contact LK Len (lk.len@science.doe.gov)

c. Magnet and Fast Kicker Technology—Advanced magnet and fast kicker technologies are needed to support the development of the ILC. Accordingly, grant applications are sought to develop:

(1) wiggler systems suitable for use in the damping rings of the ILC. Both permanent magnet and superconducting magnet systems are of interest. Over one damping time, the uniformity of the wiggler field must be sufficient to provide a dynamic aperture of approximately 10 sigma, as determined by tracking particles characteristic of the injected positron beam. The wiggler physical aperture must provide an acceptance of approximately 5 sigma.

(2) fast kicker systems useful for single bunch injection/extraction systems in the ILC damping rings. The rise and fall time of the field seen by the beam must be close to 3-4 ns. The overall system (possibly consisting of a number of kicker modules) should be capable of delivering a 0.6 mrad kick to a 5 GeV electron beam. The kicker should be capable of burst operation at 3 MHz for a duration of up to 1 ms, at a repetition rate of 5 Hz.

(3) short-period helical undulators, suitable for use with a high-energy (>150 GeV) electron beam, to produce an intense 10 MeV photon beam. (The photons subsequently would be used to produce showers in a thin target, providing an undulator-based positron source for the ILC.) The undulator field, gap, and period must be consistent with the requirements of the ILC undulator-based source.* [reference 1]

(4) quadrupole focusing systems, capable of achieving the demagnification needed at the interaction point of the ILC, while satisfying the geometry constraints imposed by the beam crossing angle and the particle detectors. [reference 2]

(5) high reliability magnet, magnet power supply, and control systems. Grant applications are sought for the development of: (a) water cooled accelerator magnets with extremely high reliability, characterized by a mean

time to failure greater than 10 million hours; (b) highly reliable power supply systems for accelerator magnets, with a mean time to failure greater than 4 million hours ; and (c) associated high-reliability electronic control systems for magnet operation.

Questions – contact LK Len (lk.len@science.doe.gov)

d. Polarized RF Photocathode Sources—Grant applications are sought for the development of polarized electron sources which operate with RF guns, and consequently can provide very low emittance beams. The cathode material should have long lifetime and high quantum efficiency, with electron polarization greater than 85%, and an rms invariant emittance of 4π mm-mrad or less. The bunch parameters and format should be those of the ILC.*

Questions – contact LK Len (lk.len@science.doe.gov)

* The ILC linac parameters include a beam intensity of $2x10^{10}$ electrons or positrons per bunch, in trains of about 3000 bunches, separated by about 300 ns. The trains themselves occur at a repetition rate of 5 Hz. Each bunch has an rms invariant transverse emittance of about 8 μm (horizontal) by 0.02 μm (vertical), with an rms bunch length of 300 μm. Beam size at the interaction point (IP) is about 6 nm vertically. The energy varies from 5 GeV at the start of the linac, to 250 GeV at the end.

References:

1 Bair, G. A., et al., "TESLA: Technical Design Report: Part II—The Accelerator," Royal Holloway Centre for Particle Physics, March 2001. (Full text available at: http://www.pp.rhul.ac.uk/hep/pubs2/2001/flc01-22.html)

2 Loew, G., et al., "International Linear Collider (ILC) Technical Review Committee: Second Report," 2003. (Report No. SLAC-R-606) (Hard copy available from National Technology Information Service at: http://www.ntis.gov)

3 "ILC-Americas Workshop," ILC at SLAC, Stanford, CA, October 2004, Stanford Linear Accelerator Center Website. (URL: http://www-project.slac.stanford.edu/ilc/meetings/workshops/US-ILCWorkshop/workshop.html)

4 "[First] ILC Workshop at KEK: Towards an International Design of a Linear Collider," Tsukaba, Japan, November 13-15, 2004 Website. (URL: http://lcdev.kek.jp/ILCWS/)

5 International Linear Collider Website. (URL: http://www.linearcollider.org/cms/)

6 "2nd ILC Accelerator Workshop," Snowmass, Colorado, USA, August 14-27, 2005 Website. (URL: http://alcpg2005.colorado.edu/)

49. ADVANCED CONCEPTS AND TECHNOLOGY FOR HIGH ENERGY ACCELERATORS

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in the following areas: (1) new concepts for acceleration,

(2) novel device and instrumentation development, (3) inexpensive electron sources, and (4) computer software for control systems and advanced accelerator modeling. Relevance to applications in HEP must be explicitly described in the submitted grant applications.

Grant applications are sought only in the following subtopics:

a. Advanced Accelerator Concepts and Modeling—Grant applications are sought to develop new or improved acceleration concepts and computational modeling tools for accelerator.

Proposed accelerator designs should provide very high gradient (>100 MV/m for electrons or >10 MV/m for protons) acceleration of intense bunches of particles, or efficient acceleration of intense (>50 mA) low energy (of order <20 MeV) proton beams. Approaches of interest include: (1) the fabrication of accelerator structures from materials such as Si or SiO_2, using integrated circuit technology, where the realization might include photonic bandgap structures powered by lasers in the wavelength range 1 to 2.5 μm; (2) the development of microcapilllary arrays with arbitrary thickness-to-diameter ratios, with capillary diameters down to 5 microns, and with different diameters and materials in the same plate (which might also incorporate defect structures such as lines and holes); and (3) the development of high-efficiency, high-power, fiber drive lasers at longer wavelengths comparable to what has been achieved for Yb doped silica fiber, but based on other dopants (e.g. Ho, Tm or Cr) and host materials (e.g. phosphate glass). For all proposed concepts, stageability, beam stability, manufacturability, and high-wall plug-to-beam power efficiency should be considered.

Grant applications are also sought to demonstrate proton acceleration in the energy range of 5-25 GeV using non-scaling, fixed-field alternating-gradient (FFAG) accelerators. This demonstration may require an electron model to directly simulate operation in a space-charge limited regime and fast RF modulation for high repetition rate. The HEP application of interest is for a proton driver injector for a neutrino factory. Other possible applications include high-intensity proton drivers for neutron production, waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy (250 MeV), and radioisotope production.

Also of interest are new concepts for the generation, capture, cooling, acceleration and colliding of intense muon beams as well as improved simulation packages for studying ionization cooling of muon beams.

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

Grant applications are also sought to develop improved simulation packages for injectors or photoinjectors. Areas of interest include: (1) improved space-charge algorithms; (2) improved algorithms for the self-consistent computation of the effects of wakefields and coherent synchrotron radiation on the detailed beam dynamics; (3) improved fully-three-dimensional algorithms for the modeling of transversely asymmetric beams; and (4) explicit end-to-end simulations that provide for more accurate beam-quality calculations in full injector systems.

Questions - contact LK Len (lk.len@science.doe.gov)

b. Novel Device and Instrumentation Development—Grant applications are sought for the development of electromagnetic, permanent magnet, or silicon microcircuit-based charged particle optical elements for particle beam focusing. Examples include, but are not limited to, dipoles, quadrupoles, higher order multipole

correctors for use in electron linear accelerators, and solenoids for use in electron-beam or ion-beam sources or for klystron or other radio frequency amplifier tubes operating at wavelengths from 0.7 to 10 cm. In these optical elements, permanent magnets or hybrid magnets incorporating magnetic materials that have very high residual magnetization, radiation resistance, and thermal stability (low variation of field strength with temperature) are of particular interest. Also of interest are undulators for bunching high energy electron beams, needed for phased injection in high frequency accelerating structures and for generating coherent transition radiation.

Grant applications also are sought for: (1) novel charged particle beam monitors to measure the transverse or longitudinal charge distribution, emittance, or phase-space distributions of small radius (0.1 μm to 5 mm diameter), short length (10 μm to 10 mm) relativistic electron or ion beams; (2) devices capable of measuring and recording the Schottky or transition radiation spectrum of these beams (proposed techniques should be nondestructive, or minimally perturbative, to the beams monitored and have computer-compatible readouts); (3) lasers for laser-accelerator applications that provide substantial improvements over currently available lasers in one or more of the following parameters: (i) longer wavelengths (up to 2 to 2.5 μm for use with Si transmissive optics), (ii) very short wavelengths (< 200 nm) with low mode numbers (M-squared < 100) and high pulse energy (> 0.1 J) for photo-ionized plasma sources, (iii) higher power, (iv) higher repetition rates, and (v) shorter pulse widths; and (4) achromatic, isochronous compact focusing systems with broad energy acceptance and compact broadband (10-100 MeV) spectrometers, suitable for use in laser acceleration experiments.

Grant applications are sought to develop high density (range of 10^{18}-10^{20} cm^{-3}), high repetition rate (≥10 Hz) pulsed gas jets, capable of producing longitudinally tailored density profiles with long lengths (centimeter scale) and narrow widths (few hundred microns) for use in laser wakefield accelerators. The gas jet should have sharp entrance gradients, with a transition region/length on the order of 500 μm. The pulse duration of the jets should be less than 500 μs to minimize the amount of gas loading in vacuum chambers. Cluster gas jets, i.e., jets that are cooled and produce atomic clusters, are also of interest.

Grant applications also are sought for the development of novel devices and instrumentation for use in producing intense low energy muon beams suitable for precision muon experiments, and intense high energy muon beams suitable for neutrino factories and/or muon colliders. Approaches of interest include the development of: (1) concepts or devices for ionization cooling, including emittance exchange processes; (2) concepts or devices for manipulating the longitudinal phase space of large emittance muon beams, including bunching, phase rotation, and bunch merging; (3) concepts or devices for producing intense polarized muon beams; (4) large aperture kickers for injection and extraction in muon cooling rings; (5) concepts for cost effective rapid acceleration; (6) instrumentation for muon cooling channels that have muon intensities of 10^{12} muons/pulse; or (7) fast (on the order of 10 picosecond) timing detectors for muon cooling experiments with low muon intensity (on the order of 10^{5} muons/second).

Lastly, grant applications are sought to develop non-scaling Fixed Field Alternating Gradient (FFAG) and Recirculating Linear Accelerator (RLA) systems for muon acceleration. For FFAG, approaches of interest include: (1) the development and analysis of FFAG designs that contain insertion sections, (2) engineering design and cost analysis of injection and extraction systems for a neutrino factory FFAG, including the effect of the kicker system on the beam dynamics, and (3) detailed analysis of the dynamics of recently proposed non-scaling FFAG designs, including such features as dynamic aperture (and how it depends on acceleration rate) and sensitivity to errors. For RLA, approaches of interest include: (1) lattice optimization for a large energy range, (2) examination of the practical upper limit to the number of passes the beam can make through an RLA, and (3) detailed design of a suitable switchyard and its magnets.

Questions - contact LK Len (lk.len@science.doe.gov)

c. Inexpensive High Quality Electron Sources—Grant applications are sought for the design and prototype fabrication of small, inexpensive (<$1 million) electron sources for use in advanced accelerator R&D laboratory experiments. The following parameters are target values for accelerator research experiments: (1) energy range of 5 to 35 MeV providing, at a minimum, on the order of 10^9 electrons in a bunch less than 5 picoseconds long; (2) normalized transverse beam emittance $\leq 5\pi$ mm-mrad; and (3) pulse repetition rate >10 Hz. Grant applications are also sought for sources with significantly lower bunch charges, energies, and emittances from a matrix cathode, but at comparable or greater peak currents and significantly higher repetition rates. In addition, grant applications are sought to develop a bright direct-current/radio-frequency (DC/RF) photocathode electron source that combines a pulsed high-electric-field DC gun and a high field RF accelerator, operates at a repetition rate of several kHz, and has electron bunch specifications similar to those listed above.

Grant applications also are sought to develop: (1) robust RF photocathodes (quantum efficiencies >0.1 percent) or other novel RF gun technologies operating at output electron beam energies >3 MeV; and (2) laser or electron driven systems for such guns.

Questions - contact LK Len (lk.len@science.doe.gov)

d. Computer Software for Control Systems

Grant applications are sought to develop: (1) improved software systems for command and control functions, real time database management, real-time or off-line modeling of the accelerator system and beam, and status display systems encountered in state-of-the-art approaches to accelerator control and optimization; and (2) improved decision and database management tools, specifically for use in planning and controlling the integrated cost, schedule, and resources in large HEP R&D and construction projects.

Grant applications are also sought to develop real-time optical networks for pulsed-accelerator control. These networks require timing information to be combined with data-communication functions on a single optical fiber connected to pulsed device-controllers. The single fiber should provide each controller with an RF-synchronized clock that has the following features: (1) an arrival time that is phase-locked to the temperature-stabilized RF reference phase, (2) a phase-locked machine pulse fiducial point, (3) digital data for machine pulse-type selection and specific pulse identification, and (4) real-time-streaming pulsed waveform data-acquisition capabilities. The controllers serve as interfaces to systems that provide such functions as low-level RF signal generation, modulator control, beam position monitors, and machine protection system sensing. The network should provide real-time, fast-feedback loop closure and TCP/IP connectivity for slow control functions such as database access, device configuration, and code downloading and debugging.

Finally, grant applications are sought to develop real-time processors and software for pulsed accelerator control and monitoring. The software should be based on a multiprocessor architecture that can be deeply embedded within pulsed device-controllers, which employ system-on-a-chip, field-programmable gate-array, or application-specific integrated circuit technologies. The architectures should feature distinct processors for real-time pulse-to-pulse functions, and conventional slow control functions. Architectural provisions for supporting machine protection functions via an additional processor or dedicated hardware also should be included.

For the preceding two paragraphs, proposed solutions should be engineered to include: (1) resistance to electromagnetic interference generated by nearby, large pulsed-power systems; and (2) maximum availability in remote deployment locations.

Questions - contact LK Len (lk.len@science.doe.gov)

References:

1 Berz, M. and Makino, K., eds., Computational Accelerator Physics 2002, Proceedings of the 7th International Conference on Computational Accelerator Physics, East Lansing, MI, October 15-18, 2002, Bristol/Philadelphia, Institute of Physics Publishing, 2005. (Institute of Physics Conference Series Number 175) (ISBN: 0-7503-09393)

2 Bisognano, J. J. and Mondelli, A. A., eds., Computational Accelerator Physics, Williamsburg, VA, September 24-27,1996, American Institute of Physics (AIP), May 1997. (AIP Conference Proceedings No. 391) (ISBN: 1-5639-66719)*

3 Chao, A. and Tigner, M., eds., Handbook of Accelerator Physics and Engineering, River Edge, NJ: World Scientific, 1999. (ISBN: 9-8102-38584)

4 "Advanced Accelerator Concepts, 12th Workshop," Lake Geneva, WI, July 10-15, 2006, U.S. DOE Argonne National Laboratory Website. (URL: http://www.hep.anl.gov/aac06/)

5 Yakimenko, V., ed., Advanced Accelerator Concepts, 11th Workshop, Stony Brook, NY, June 21-26, 2004, New York: American Institute of Physics, 2004. (AIP Conference Proceedings No. 737) (ISBN: 0-7354-02205)*

6 Duggan, J. L. and Morgan, I. L., eds., Application of Accelerators in Research and Industry: Proceedings of the Seventeenth International Conference on the Application of Accelerators in Research and Industry, Denton, TX, November 12-13, 2002, New York: American Institute of Physics, August 2003. (AIP Conference Proceedings No. 680) (ISBN: 0-7354-01497)*

7 Shea, T. and Sibley R., III, eds., Beam Instrumentation Workshop 2004: Eleventh Beam Instrumentation Workshop, Knoxville, TN, May 3-6, 2004, American Institute of Physics, 2004. (AIP Conference Proceedings No. 732) (ISBN: 0-7354-02140)*

8 Ko, K. and Ryne, R., eds., "Proceedings of the 1998 International Computational Accelerator Physics Conference: ICAP '98," Monterey, CA, September 14-18, 1998, Stanford, CA: Stanford Linear Accelerator Center, November 2001. (Document No. SLAC-R-580) (Full proceedings available at: http://www.slac.stanford.edu/econf/C980914.)

9 Kurokawa, S., et al., eds., Beam Measurement: Proceedings of the Joint US-CERN-Japan-Russia School on Particle Accelerators, Montreux and CERN, Switzerland, May 11-20, 1998, River Edge, NJ: World Scientific, 1999. (ISBN: 9-8102-38819)

10 Lee, S. Y., Accelerator Physics, River Edge, NJ: World Scientific, 1999. (ISBN: 9-8102-37103)

11 Rosenzweig, J. and Serafini, L., eds., The Physics of High Brightness Beams: Proceedings of the 2nd ICFA Advanced Accelerator Workshop, Los Angeles, CA, November 9-12, 1999, River Edge, NJ: World Scientific, 2000. (ISBN: 9-8102-44223)

12 "Eighth International Workshop on Neutrino Factories, Superbeams and Betabeams, NuFact 06," Irvine, CA, August 24-30, 2006 Website. (URL: http://nufact06.physics.uci.edu/)

13 Para, A., ed., Neutrino Factories and Superbeams: 5th International Workshop on Neutrino Factories and Superbeams NuFact 03, New York, NY, June 5-11, 2003. New York: American Institute of Physics, October 2004. (AIP Conference Proceedings No. 721) (ISBN: 0-7354-02019)*

14 Zimmermann, F., et al., "Potential of Non-Standard Emittance Damping Schemes for Linear Colliders," presented at: 3rd Asian Particle Accelerator Conference APAC 2004, Gyeongiu, Korea, March 22–26, 2004. (URL: http://cdsweb.cern.ch/search.py?recid=728895&ln=en, http://clic-meeting.web.cern.ch/clic-meeting/2004/04_30fz.pdf)

* Abstracts and ordering information available at: http://proceedings.aip.org/proceedings/.

50. RADIO FREQUENCY ACCELERATOR TECHNOLOGY FOR HIGH ENERGY ACCELERATORS AND COLLIDERS

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in: (1) high gradient accelerator structures, (2) high peak power radio frequency (RF) technologies, and (3) new concepts for low-cost, very efficient, pulse power modulators. Relevance to applications in HEP must be explicitly described.

Grant applications are sought only in the following subtopics:

a. Radio Frequency Acceleration Structures—Grant applications are sought for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >150 MV/m for electrons and >10 MV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and reducing costs. In muon accelerator R&D, structures for capture and acceleration of large emittance muon beams and techniques for achieving gradients of 5-20 MV/m in cavities with frequencies between 5 and 400 MHz (including superconducting cavities whose resonant frequencies can be rapidly modulated) are of interest. Methods for reducing surface breakdown and multipactoring (such as spark-resistant materials or surface coatings, or special geometries) and for suppressing unwanted higher order modes also are of interest, as are studies of surface breakdown and its dependence on magnetic field. Grant applications should be applicable to devices operating at frequencies from 1 to 40 GHz, or between 5 and 400 MHz for muon accelerators.

Grant applications are also sought to develop simulation tools for modeling high-gradient structures, in order to predict such experimental phenomena as the onset of breakdown, post breakdown phenomena, and the damage threshold. Specific areas of interest include the modeling of: (1) surface emission, (2) material heating due to electron and ion bombardment, (3) multipactoring, and (4) ionization of atomic and molecular species. Approaches that include an ability to import/export CAD descriptions, a friendly graphical user interface, and good data visualization will be a plus.

Other areas of interest include the development of: (1) new materials that are suitable for the fabrication of superconducting radiofrequency (SRF) cavities, such as large grain or single crystal Nb; and (2) new or improved SRF cavity fabrication techniques especially weld-free approaches.

Questions - contact LK Len (lk.len@science.doe.gov)

b. Radio Frequency Power for Linear Accelerators—Grant applications are sought to develop new concepts, high-power RF components, and instrumentation for use in producing high peak power in narrow-band, low-duty-cycle, and low-pulse-repetition-frequency (approximately 0.1 to 1 kHz) pulsed RF amplifiers. The principal application will be for future large multi-TeV electron/positron linear colliders. Of particular interest

are innovations related to cost saving, manufacturability, and electrical efficiency. Also of interest are RF sources for high-gradient accelerator research. Innovations that allow the source to be configured for different frequencies at low cost are of particular interest. Grant applications are also sought to develop electron beam sources, such as sheet or elliptical beams, relevant to the abovementioned high power RF applications.

The next generation of multi-TeV linear colliders will require many RF power handling components which are not presently available, e.g., RF windows, couplers, mode transformers, RF loads, and high power rings capable of operating at high pulse powers. Consequently, grant applications are sought to develop active or passive RF pulse compression systems capable of handling peak powers, for example, 150-200 MW and 100-200-nanosecond pulsewidth at 30 GHz. Grant applications also are sought for passive and active RF components such as over-moded mode converters (e.g., rectangular to circular waveguide and vice versa), high-power RF windows, circulators, isolators, switches, and quasi-optical components.

Lastly, grant applications are sought for new concepts, approaches, or designs for radio-frequency amplifiers, or pulse compression schemes, for use in the acceleration and ionization cooling channels of a future muon collider. The amplifiers or compressors must have high peak power (>30 MW) and pulsed, low frequency (from 2 ms pulses at 20 MHz to 0.1 ms pulses at 200 MHz). Higher power (>100 MW) pulsed sources at higher frequencies, e.g., 30 μs at 400 MHz, also are of interest. All muon collider amplifiers must have moderate repetition rate capability (e.g., 50 Hz). Grant applications should address the cost per unit of peak power, including the cost of required power supplies.

Questions - contact LK Len (lk.len@science.doe.gov)

c. New Concepts or Components for Pulsed Power Modulators and Energy Storage—Most RF power sources for future linear colliders require high peak-power pulse modulators of considerably higher efficiency than presently available. Grant applications are sought for new types of modulators in the 400 kV – 1 MV range for driving currents of 200 - 800 A, with pulse lengths of 0.2 – 5.0 μs, and with rise- and fall-times less than 0.5 μs. Grant applications also are sought for the development of modulators with improved voltage control for RF phase stability in some alternate RF power systems, as well as cathode modulators that are compact and cost competitive compared to present cathode pulse modulator schemes. Grant applications should address issues related to cost saving, manufacturability, and electrical efficiency in modulators.

Grant applications are also sought to develop improved high power solid-state switches for pulse power switching. For some applications, requirements will include the ability to switch high current pulses (2-5 kA) at voltage levels of 2 to 6 kV, with switching times less than 300 nsec. These switches must handle very high di/dt (20 kA/μs) at low duty cycle (<0.1%).

Existing Insulated Gate Bipolar Transistor (IGBT) packages for high voltage and high pulsed current (e.g., V = 6.5 kV, I = 3 kA peak, 800 A average) are not optimized for very high speed pulsed power applications (10 MW peak for 3.2 μs at 120 Hz) due to failure modes induced by very rapid fall times (di/dt >10 kA/μs) and/or rise times (dV/dt >15 kV/μs) upon device turn-off. Therefore, grant applications are sought to reduce these failure modes through improved packaging of commercial IGBT chips, by incorporating appropriate protective circuitry in a high voltage power package designed specifically for high-speed transients.

Lastly, grant applications are sought to develop and optimize high reliability, high-energy-density energy storage capacitors for future solid state pulse power systems. The capacitors must: (1) deliver high peak pulse current (5 - 8 kA) in the partial discharge region (less than 10 percent voltage droop during pulse); (2) be designed with very low inductance connections to allow fast rise and fall time discharge without ringing (di/dt ~ 20 kA/μs); and (3) be packaged to meet the requirements of high power solid state board layouts and have minimum production cost.

Questions - contact LK Len (lk.len@science.doe.gov)

References:

1 Abe, D. K. and Nusinovich, G. S., eds., High Energy Density and High Power RF: 7th Workshop on High Density and High Power RF, Kalamata, Greece, June 13-17, 2005, New York: American Institute of Physics (AIP), 2006. (AIP Conference Proceedings No. 807) (ISBN: 0-7354-02981)*

2 Cline, D. B., ed., Muon Collider Studies, Physics Potential and Development of Colliders, Fourth International Conference, San Francisco, CA, December 1997, pp. 183-344, American Institute of Physics, 1998. (AIP Conference Proceedings No. 441) (ISBN: 1-5639-67235)*

3 "Advanced Accelerator Concepts, 12th Workshop," Lake Geneva, WI, July 10-15, 2006, U.S. DOE Argonne National Laboratory Website. (URL: http://www.hep.anl.gov/aac06/)

4 Yakimenko, V., ed, Advanced Accelerator Concepts, 11th Workshop, Stony Brook, New York, June 21-26, 2004, New York: American Institute of Physics, 2004. (AIP Conference Proceedings No. 737) (ISBN: 0-7354-02205)*

5 "Twenty-Second International Linear Accelerator Conference, LINAC 2004," Lubeck, Germany, August 16-20, 2004, Website. (URL: http://www.linac2004.de/)

6 Kirkici, H., ed., Proceedings of the 26th International Power Modulator Symposium and 2004 High Voltage Workshop, San Francisco, CA, May 23-26, 2004. (IEEE Catalog Number: 04CH37588) (ISBN: 0-7803-85861)

7 Duggan, J. L. and Morgan, I. L., eds., Application of Accelerators in Research and Industry: Seventeenth International Conference on the Application of Accelerators in Research and Industry, Denton, TX, November 12-13, 2002, New York: American Institute of Physics, August 2003. (AIP Conference Proceedings No. 680) (ISBN: 0-7354-01497)*

8 King, B., ed., Colliders and Collider Physics at the Highest Energies: Muon Colliders at 10 TeV to 100 TeV: HEMC '99 Workshop, Montauk, NY, Sept. 27- Oct. 1, 1999, New York: American Institute of Physics, 2000. (AIP Conference Proceedings No. 530) (ISBN: 1-5639-6953X)*

9 Horak, C., ed., Proceedings of the 2005 Particle Accelerator Conference, Knoxville, TN, May 16-20, 2005, Institute of Electrical and Electronics Engineers (IEEE), 2005. (IEEE Catalog: 05CH37623C) (ISBN: 0-7803-88607);

10 "Eighth International Workshop on Neutrino Factories, Superbeams and Betabeams, NuFact 06," Irvine, CA, August 24-30, 2006 Website. (URL: http://nufact06.physics.uci.edu/)

11 Para, A., ed., Neutrino Factories and Superbeams: 5th International Workshop on Neutrino Factories and Superbeams NuFact 03, New York, NY, June, 5-11, 2003. New York: American Institute of Physics, October 2004. (AIP Conference Proceedings No. 721) (ISBN: 0-7354-02019)*

* Abstracts and ordering information available at: http://proceedings.aip.org/proceedings/

51. HIGH-FIELD SUPERCONDUCTOR AND SUPERCONDUCTING MAGNET TECHNOLOGIES FOR HIGH ENERGY PARTICLE COLLIDERS

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in high-field superconductor and superconducting magnet technologies. This topic addresses only those superconductor and superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems.

Grant applications are sought only in the following subtopics:

a. High-Field Superconductor Technology—Grant applications are sought to develop new or improved superconducting wire technologies for magnets that operate at a minimum of 12 Tesla (T) field, with increases up to 15 to 20 T sought in the near future (three to five years). Vacuum requirements in accelerators and storage rings favor operating temperatures of 1.8 to 20 K. Stability requirements for magnets dictate that the effective filament diameter should be less than 30 micrometers. Upgrades of existing particle accelerators will require some magnets that operate under a high radiation (and thermal) load. New or improved technologies must demonstrate: (1) property improvements such as higher critical current densities and higher upper critical fields, (2) the manageable degradation of these properties as a function of applied strain, and (3) low losses in changing transverse magnetic fields, such as for twisted round multifilamentary wires. Any proposed process improvements must result in equivalent performance at reduced cost. All grant applications must focus on conductors that will be acceptable for accelerator magnets, especially with regard to the operating conditions mentioned above, and must address plans to physically deliver a sufficient amount of material of 1 km minimum length for winding and testing in small dipole or quadrupole magnets.

Grant applications also are sought to develop improvements in the starting raw materials and the basic superconducting materials for:

- Niobium-titanium (Nb-Ti) alloys. High performance Nb-Ti alloys operating above 8 T continue to be required for focusing quadrupole magnets or for graded windings in the low-field portions of high-field magnets; therefore, grant applications are sought to develop Nb-Ti composite superconductors with properties optimized at 8 T fields and higher at 4.2 K.

- A-15 compounds, such as Nb_3Sn and Nb_3Al. A minimum current density of 1800 A mm^{-2} at 15 T and 4.2 K must be achieved in the superconductor itself.

- High-temperature superconductors (HTS), such as $Bi_2Sr_2CaCu_2O_8$ and $YBa_2Cu_3O_{7-\delta}$. A minimum current density of 1200 A mm^{-2} (not A cm^{-2}) must be achieved in the superconductor itself, and a minimum current density of 250 A mm^{-2} must be achieved over the total conductor cross section at 12 T minimum and 4.2 K.

- Magnesium diboride (MgB_2) and its alloyed variants. Present wires are characterized by a filling factor that is too low, wire cross-sections that have too few filaments, and upper critical and irreversibility fields that are too low; therefore, grant applications should seek to improve the current density over the wire cross-section, implement restacked round-wire multifilamentary designs, and extend the field at which a critical current density can be attained over the superconductor cross-section of 1200 A mm^{-2} in the 12-16 T range at 4.2 K.

Grant applications also are sought to develop: (1) innovative wire and cable design and processing technologies, and (2) innovative insulating materials that are compatible with the use of intermetallic superconductors in practical devices. Innovative wire processing technologies of interest include methods to utilize stranded conductors with high aspect ratio, such as Rutherford cables, or low-loss tape geometries in particle accelerator applications; technologies to improve wire piece length and increase billet mass also are of interest. Innovative insulating materials should enable the use of intermetallic superconductors (such as the A-15, HTS, or MgB_2 types) in practical devices. Insulating systems must: be compatible with high temperature reactions in the 750-900 ºC range; be capable of supporting high mechanical loads at both room and cryogenic temperatures; have a high coefficient of thermal conductivity; be resistant to radiation damage; and exhibit low creep and low out-gassing rates when irradiated.

Questions - contact Bruce Strauss (bruce.strauss@science.doe.gov)

b. Superconducting Magnet Technology—Grant applications are sought to develop: (1) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (2) improved current leads based on high-temperature superconductors for application to high-field accelerator magnets, which have requirements that include an operating current level of 5 kA or greater, stability, low heat leak, and good quench performance; (3) alternative designs, to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets, that may be more compatible with the more fragile A-15, and the HTS, high-field superconductors; (4) designs for bent (e.g., bending radius in the range 0.75 to 1.25m) solenoids (e.g., 2 T, 30 cm inside diameter) with superimposed dipole fields (e.g., 1 T) for dispersion generation in large emittance beams; (5) improved industrial fabrication methods for magnets such as welding and forming; or (6) improved cryostat and cryogenic techniques.

Questions - contact Bruce Strauss (bruce.strauss@science.doe.gov)

References:

1 Balachandran, U., et al., eds., Advances in Cryogenic Engineering Materials, Proceedings of the Cryogenic Engineering Conference, Keystone, CO 2005, Vol. 52 A & B, New York: American Institute of Physics (AIP), 2006. (ISBN: 0-7354-03163)*

2 Cifarelli, L. and Mariatato, L., eds., Superconducting Materials for High Energy Colliders, Proceedings of the 38th Workshop of the INFN Eloisatron Project, Erice, Italy, October 19-25, 1999, River Edge, NJ: World Scientific, 2001. (ISBN: 9-8102-43197)

3 Duggan, J. L. and Morgan, I. L., eds., Application of Accelerators in Research and Industry, Proceedings of the 17th International Conference on the Application of Accelerators in Research and Industry, Denton, TX, November 12-13, 2002, New York: American Institute of Physics, August 2003. (AIP Conference Proceedings No. 680) (ISBN: 0-7354-0149-7)*

4 Chew, J., et al., eds., Proceedings of the 2003 Particle Accelerator Conference, Portland, Oregon, May 12-16, 2003, Institute of Electrical and Electronics Engineers (IEEE), 2003. (ISBN: 0-7803-77399)

5 Mess, K. H., et al., Superconducting Accelerator Magnets, River Edge, NJ: World Scientific, 1996. (ISBN: 9-8102-27906)

6 "The 2000 Applied Superconductivity Conference," Virginia Beach, VA, September 17-22, 2000, *IEEE Transactions on Applied Superconductivity,* 3 Parts, 11(1), March 2001. (ISSN: 1051-8223)

7 "The 2002 Applied Superconductivity Conference," Houston, TX, August 4-9, 2002, *IEEE Transactions on Applied Superconductivity,* 3 parts, 13(2), June 2003. (ISSN: 1051-8223)

8 "The 2004 Applied Superconductivity Conference," Jacksonville, FL, October 3-8, 2004, *IEEE Transactions on Applied Superconductivity,* 3 parts, 15(2), June 2003. (ISSN: 1051-8223)

* Abstracts and ordering information available at: http://proceedings.aip.org/proceedings/

52. HIGH ENERGY PHYSICS DETECTORS

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

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. Nonetheless, applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. On-line directories of appropriate researchers are available at http://www.hep.net/sites/directories.html.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly (with respect to radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc.). Electromagnetic calorimeters, also called shower counters or gamma ray detectors, must be optimized for photons with energies above 1 GeV. X-ray detectors are not relevant to this topic.

Grant applications are sought only in the following subtopics:

a. Particle Detection and Identification Devices—Grant applications are sought for novel devices in the areas of charged and neutral particle detection and identification. Examples include, but are not limited to, semiconductor particle detectors (silicon, CVD diamond, or other semiconductors), light-emitting particle detectors (scintillating materials including fibers, liquids, and crystals or Cherenkov radiators), photosensitive detectors that could be used with light-emitting detectors (photomultipliers, micro-channel plates, photosensitive semiconductors), and gas or liquid-filled chambers (used for particle tracking, in electromagnetic or hadronic calorimeters, and in Cherenkov or transition radiation detectors). Grant applications also are sought for systematic studies of radiation aging of materials used in particle detectors.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

b. Detector Support and Integration Components—HEP experiments frequently require high performance detector support that will not compromise the precision of the detectors. Therefore, grant applications are sought for components used to support or integrate detectors into HEP experiments. The support components must be well matched to the detectors and possess some or all of the following features: low mass, high strength or stiffness, low intrinsic radioactivity, exceptionally high or exceptionally low thermal conductivity, and low cost. Grant applications also are sought for alignment systems, cooling systems, and radiation-hard low voltage power supplies for digital and analog electronics.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

References:

1 Abe, F., et al., "The CDF Detector: An Overview," *Nuclear Instruments & Methods in Physics Research,* Section A–Accelerators, Spectrometers, Detectors and Associated Equipment, 271(3): 387-403, September 1988. (ISSN: 0168-9002)

2 Amidei, D., et al., "The Silicon Vertex Detector of the Collider Detector at Fermilab," *Nuclear Instruments & Methods in Physics Research,* Section A, 350(1-2): 73-130, October 15, 1994. (ISSN: 0168-9002)

3 Bock, R. K. and Regler, M., "Data Analysis Techniques in High Energy Physics Experiments," Cambridge, MA: Cambridge University Press, 1990. (ISBN: 0-5213-41957)

4 Bromley, D. A., "Evolution and Use of Nuclear Detectors and Systems," *Nuclear Instruments and Methods in Physics Research*, 162(1-3): 1-8, June 15, 1979. (ISSN: 0029-554X)

5 Cline, D. B., "Low-Energy Ways to Observe High-Energy Phenomena," *Scientific American*, 271(3): 40-47, September 1994. (ISSN: 0036-8733)

6 Duggan, J. L. and Morgan, I. L., eds., Application of Accelerators in Research and Industry: Proceedings of the 15th International Conference on the Application of Accelerators in Research and Industry, Denton, TX, November 4-7, 1998, New York: American Institute of Physics, 1999. (ISBN: 1-56396-825-8) (AIP Conference Proceedings No. 475) (Abstracts and ordering information available at: American Institute of Physics Conference Proceedings sub-series: *Accelerators, Beams, Instrumentation* at: http://proceedings.aip.org/proceedings/accelerators.jsp)

7 Kleinknecht, K., Detectors for Particle Radiation, Cambridge, MA: Cambridge University Press, 1986. (ISBN: 0-5213-04245)

8 Litke, A. M. and Schwarz, A. S., "The Silicon Microstrip Detector," *Scientific American*, 272(5):76-81, May 1995. (ISSN: 0036-8733)

9 Perkins, D. H., An Introduction to High Energy Physics, Addison-Wesley Longman, 1982. (ISBN: 0-2010-57573)

OFFICE OF NUCLEAR ENERGY, SCIENCE AND TECHNOLOGY

53. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Nuclear power provides over 20 percent of the U.S. electricity supply without emitting harmful 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 enhancing resistance to nuclear proliferation. This topic addresses several of these key technology areas: improvements in nuclear reactor technology for existing reactors and evolutionary designs, advanced instrumentation and control (I&C) for very high temperature reactor applications, advanced I&C for use in high radiation environments for Generation IV reactor designs, and advanced techniques for spent-reactor-fuel separations technology and devices. Of particular interest are grant applications that propose the use of the Idaho National Laboratory's Advanced Test Reactor for Phase I and/or Phase II. However, grant applications that deal with nuclear materials, irradiation effects, chemistry, and/or corrosion research are also not of interest for this topic and should be submitted instead under Topic 5.

Grant applications are sought only 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 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]; (2) to improve monitoring of plant equipment performance and aging, using improved diagnostic techniques for in-service and non-destructive examinations; (3) for advanced instrumentation, sensors, and controls for very high temperature Generation IV reactor designs that can withstand temperatures in excess of 1300° C; (4) for advanced instrumentation, sensors, and controls for the very high irradiation environments that will be encountered in advanced Generation IV high temperature gas reactor designs; and (5) to develop light water reactor, spent reactor fuel separations technology and devices that are compatible with the UREX+ process [Ref. 7, 8] and that allow for fission product separation of highly radioactive, low-atomic-mass isotopes from spent transuranic and minor actinide wastes (e.g. Pu, Np, Am, Cm, etc), without explicit plutonium separation, in order to enhance proliferation resistance as required for the GNEP and AFCI programs [Ref. 7, 8].

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

Questions - contact Dr. Madeline Feltus (madeline.feltus@nuclear.energy.gov)

b. Advanced Computational Methods for Generation IV Nuclear Power Applications—Improvements and advances are needed for simulating reactor systems and component technologies that ultimately would be used in the design, construction, or operation of existing and future nuclear power plants, advanced fast reactors, and Generation IV nuclear power systems [See References]. Grant applications are sought for advanced computational methods that involve advanced reactor/core computer simulations for Generation IV nuclear energy technology, including: (1) advanced reactor design model code development; (2) coupled/parallel thermal-hydraulic/neutron physics tools; (3) safety and performance evaluation methods, and engineering calculations, for new Generation IV gas-cooled high temperature thermal reactors and sodium-cooled fast reactor designs – and for their major reactor components, reactor cores, and fuel assemblies; (4) *ab initio* nuclear cross section and data development methods, for Generation IV gas-cooled reactors and GNEP reactor designs; and (5) advanced graphic user-interfaces (GUIs) that use existing nuclear computer codes and simulation methods for very large-scale and petascale computers.

Grant applications that address the following areas of investigation are NOT of interest and will be declined: generalized thermal-hydraulics analysis (e.g. CFD or two-fluid codes); probabilistic risk assessment tools or methods; reactor/core computer simulation methods for existing light water reactor designs, or computer simulations for personal computers or workstations.

Questions - contact Dr. Madeline Feltus (madeline.feltus@nuclear.energy.gov)

References:

1 Moving Ahead with a Nuclear Age, U.S. DOE Office of Nuclear Energy, Home Page. (URL: http://www.nuclear.gov)

2 Generation IV Nuclear Energy Systems, Office of Nuclear Energy, (URL: http://nuclear.energy.gov/genIV/neGenIV1.html)

3 Nuclear Energy Research Initiative (NERI), Office of Nuclear Energy, Science and Technology. (URL: http://nuclear.energy.gov/neri/neNERIresearch.html)

4 Nuclear Power 2010, Office of Nuclear Energy. (URL: http://nuclear.energy.gov/np2010/neNP2010a.html. See also http://nepo.ne.doe.gov/)

5 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.science.doe.gov/sbir/NE1_ICHMI_Report.pdf)

6 Hallbert, Bruce P., et al., "Technology Roadmap on Instrumentation, Control, and Human Machine Interface to Support DOE Advanced Nuclear Power Plant Programs," INL/EXT-06-11862, November 2006. (Full text, available at: http://rclsgi.eng.ohio-state.edu/nuclear/ACE/index_files/ichmi_roadmap.pdf)

7 Global Nuclear Energy Partnership Technology Development Plan, Office of Nuclear Energy, GNEP-TECH-TR-PP-2007-00020, Rev 0. (Full text available at: http://www.gnep.energy.gov/pdfs/gnep-tdp-0020_Jul_25_2007.pdf)

8 Global Nuclear Energy Partnership (GNEP), U. S. Department of Energy. (URL: http://www.gnep.energy.gov/ and http://www.gnep.energy.gov/gnepPublicInformation.html)

OFFICE OF SCIENCE

54. SEARCH, DISCOVERY, AND COMMUNICATION OF SCIENTIFIC AND TECHNICAL KNOWLEDGE IN DISTRIBUTED SYSTEMS

Scientific discovery underpins the advances the Nation needs to power our economy and develop energy independence. As science progresses only if knowledge is discovered and shared, the acceleration of the sharing of scientific knowledge speeds up scientific progress. In today's world, this knowledge is embodied in text (journal articles, e-prints, conference proceedings, report literature) as well as in many digitized non-text formats (numeric data, images, video, streaming media, and more) hosted on geographically dispersed servers. Researchers would benefit greatly if they had ways to simultaneously search across these vast resources of text

and/or non-text and find the specific knowledge they need in an integrated manner. While technology has significantly accelerated the availability and quantity of scientific information on the Web, the tools and capabilities to search and find that information have not kept pace with its growth. This lag has created a chasm in the capability to globally search the Internet, especially with regard to distributed scientific and technical information of merit.

Grant applications are sought only in the following subtopic.

a. Web-Based Tools and Deployable Concepts to Accelerate and Facilitate search, Discovery, and Communication of Scientific and Technical Knowledge—Grant applications are sought to develop technology to accelerate and facilitate the search, discovery, and communication of scientific and technical information in its many varied digital forms and formats. Areas of particular interest include advances in clustering; federated searching of the deep web; discovery of numeric data sets; wireless applications for scientific communication; manipulation/modification of metadata, along with its relation to full text data, for the purpose of improved analysis and precision relevance ranking; and innovative techniques to increase the body of digitized literature from non-digitized sources, at lower costs than with traditional digitization technology. Proposed approaches must emphasize the development of user-friendly tools and deployable concepts across the broad spectrum of worldwide science.

Questions - contact Dr. Walter L. Warnick (Walter.warnick@science.doe.gov)

References:

1 **"**Workshop Panel Report on Accelerating the Spread of Knowledge About Science and Technology: An Examination of the Needs and Opportunities**"** (Full text available at**:** http://www.osti.gov/publications/2007/workshop.pdf)

2 "WorldWideScience.org Global Science Gateway" (Full text available at**:** http://www.osti.gov/news/transcripts/wwstranscript)

3 *"*DOE Science Accelerator: Advancing Science by Accelerating Science Access," U.S. DOE Office of Science and Office of Scientific and Technical Information (OSTI), June 2006. (Full text available at**:** http://www.osti.gov/innovation/scienceaccelerator.pdf)

4 "Overview," *2020 Science* Website, Microsoft Research. (URL: http://research.microsoft.com/towards2020science/background_overview.htm)

5 "Science Conferences," U.S. DOE Office of Scientific and Technical Information (OSTI) Website. (URL: http://www.osti.gov/scienceconferences)

6 *"*Energy Science and Technology Virtual Library: Energyfiles, U.S. DOE OSTI Website. (URL: http://www.osti.gov/energyfiles/pathways.html)

7 "GrayLit Network," U.S. DOE OSTI Website. (URL: http://www.osti.gov/graylit)

8 "Federal R&D Project Summaries," U.S. DOE OSTI Website (URL: http://www.osti.gov/fedrnd)

9 "E-Print Network," U.S. DOE OSTI Website. (URL: http://www.osti.gov/eprints)

OFFICE OF FOSSIL ENERGY

55. POWER GENERATION TECHNOLOGIES FOR COAL-BASED POWER PLANTS

Improved power generation technologies will help the nation make more efficient and environmentally-responsible use of its abundant domestic coal reserves. Accordingly, this topic seeks advances in solid oxide fuel cell (SOFC) technology for central coal power plants and in turbine combustion for Integrated Gasification Combined Cycle (IGCC) power plants.

SOFC-based systems are attractive alternatives to current technologies in large-scale stationary applications. SOFC systems are very efficient, with efficiencies ranging from 40 to 60 percent (depending on system size) and up to 85 percent in large co-generation applications. Electro-chemical conversion in a SOFC takes place at lower temperatures (650ºC to 850ºC) 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 CO_2 generation (as a result of higher efficiency) and increased CO_2 capture. With these advantages, systems containing improved fuel cell technology, in combination with heat recovery subsystems and commercial CO_2 capture technology, have the potential to meet DOE goals that include 45-50% efficiency (coal HHV to electrical power), <15ppm NOx, and 90% carbon capture. Consistent with these goals, the DOE-sponsored Solid State Energy Conversion Alliance (SECA) will develop commercially-viable ($400/kW) SOFC power generation systems by the year 2010. Subtopics a and b seek R&D on high temperature cathode recycle blowers for MW-class SECA SOFC systems and on concepts for the direct utilization of coal in fuel cells.

IGCC based systems 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 criteria pollutants and particulates. Subtopics c and d seek advances in combustion modeling and Oxy-Syngas combustion, two enabling technologies for higher efficiencies and lower emissions.

Grant applications are sought only in the following subtopics.

a. High-Temperature Cathode Recycle Blowers—SOFC-based power block configurations for coal-fueled central generation applications could benefit (with respect to overall plant efficiency) from recycling a portion of the high-temperature (e.g., 800-850°C) cathode air effluent back to the incoming cathode air stream. Systems studies have indicated that a recycle ratio of forty to fifty percent (40-50%) would be desirable to assist in preheating incoming cathode air to the required stack inlet temperature (e.g., 600-650C). In order to enable this recycling, grant applications are sought to design and develop blowers for use in the 5MWe nominal SECA SOFC-based proof-of-concept (POC) systems to be tested at FutureGen, the world's cleanest coal-based power plant, in 2012. The two most important considerations for this component are: (1) reliability, which is critical to ensure safe long-term system operation; and (2) cost.

Specific blower performance specifications will be dependent upon the design of the SOFC system with which it is associated; nevertheless, the following representative nominal requirements, in lieu of design-specific data, are provided and should be addressed within the grant application:

- The working fluid is atmospheric air (inlet).
- The pressure ratio is approximately 1.1 to 1.2.

- The maximum required flowrate will be determined by the SOFC configuration, and is therefore developer-dependent. For example, each SOFC building block module may have its own recycle blower – building block modules may be sized from 500kW to 1MW or more.
- The unit should be capable of variable speed control with a turn-down ratio of at least 2:1.
- The blower unit must have a design life of 40,000 hours, with a 100% duty cycle and 10,000 hour maintenance interval.
- The issue of contamination of the process air (e.g., the introduction of grease or oil) must be addressed, as the introduction of foreign matter may have an adverse effect on the SOFC cathode.

Applicants are encouraged to consult with the SECA Industry Teams with respect to their respective detailed specifications for this component.

Questions - contact Travis Shultz (travis.shultz@netl.doe.gov)

b. Direct Utilization of Coal in Fuel Cells—High- and intermediate-temperature fuel cells offer significant advantages in the direct conversion of coal to electrical power. Systems incorporating such technologies have the potential to eliminate complex and costly intermediate coal gasification and clean-up processes. High fixed and volatile carbon conversion may facilitate carbon capture. In concert with bottoming cycles to utilize waste heat (e.g., Rankine), such systems are expected to achieve very high efficiencies.

Grant applications are sought to identify and characterize fuel cell concepts that directly utilize coal to produce electrical power. Approaches of interest must focus on the development and evaluation of system concepts incorporating direct coal-fueled fuel cell stacks. Of particular importance is the ability to: (1) achieve 60 percent overall efficiency (coal HHV to electrical power) and (2) capture greater than 90 percent of the carbon contained in the coal feed. In addition, the fuel cell concept should be evaluated experimentally. The characterization should include fuel utilization, power density, degradation, emissions, etc. Illinois #6 coal is recommended for this study. Lifetime effects (phase stability, thermal expansion compatibility, relevant degradation mechanisms, etc) should be considered and characterized to the maximum extent possible.

Questions - contact Travis Shultz (travis.shultz@netl.doe.gov)

c. Turbulent Combustion Model Development for Fuel-Flexible Combustors—Most of the existing Large Eddy Simulation (LES) sub-grid combustion models are extensions of Reynolds Averaged Navier Stokes (RANS) models and thus suffer the same limitations in terms of applicability. Even LES-specific sub-grid models such as the Thickened Flame (TF) model [1] or the Filtered Density Function (FDF) approach [2] are limited in terms of their ability to be applied over a wide range of premixed combustion regimes (e.g., laminar flamelet, thickened flame, well-stirred regimes). For instance, it is not obvious that these two models can capture the effects of preferential molecular diffusion, which may occur with lightweight fuels such as hydrogen. Therefore, a modeling tool that can predict the effects of fuel composition and operating conditions on combustor performance (including such features as flame anchoring, flashback, blowout, etc.) would prove invaluable in designing fuel-flexible combustors as well as in enabling the application of opportunity fuels in the current fleet of natural gas combustors. While the focus of this solicitation is on premixed combustion, it is recognized that incomplete fuel-air mixing is an inherent fact of practical combustors.

Grant applications are sought to develop and validate innovative LES sub-grid combustion models for application in low NOx, fuel-flexible combustors. The proposed model must: (1) be applicable over a wide range of (premixed) combustion regimes, consistent with the Office of Fossil Energy's Turbine program goals for low NOx combustion (http://www.fossil.energy.gov/programs/powersystems/turbines/index.html); (2) be able to account for molecular transport effects and finite-rate chemistry; (3) cover a wide range of fuel types

(from methane to syngas, and even pure hydrogen); and (4) address the additional difficulty that the combustor may run over a wide range of operating pressures (and hence turbulent Reynolds numbers). Flame stretch, quenching and re-ignition are deemed to be important turbulent combustion phenomenon for gas turbine combustors.

Any proposed LES sub-model must be computationally efficient, such that it could be used for combustor development at industrial time scales (i.e. acceptable computational time). For example, a sub-model that increases the LES computational time by 10-fold would not meet this requirement. The goal is to develop sub-grid combustion modeling approaches for LES that could be implemented in a wide range of LES combustion codes. The development of LES codes themselves, or the development of proprietary modeling approaches with limited application, are not of interest.

Questions - contact Rondle Harp (rondle.harp@netl.doe.gov)

d. Oxy-Syngas Re-Heat Combustor—One of the more promising technologies that can enable high-efficiency coal-based power generation with near 100% CO_2 capture is the oxy-syngas process. In this process, coal-derived syngas is combusted with pressurized oxygen, in the presence of water and/or steam, to produce a steam/CO_2 working fluid for turbines. This stream is expanded through one or more turbines to generate power, before it enters a condenser in which the CO_2 is separated from the water. The CO_2 then is conditioned and delivered to a sequestration site. Systems analyses have shown that oxy-syngas cycle efficiencies can be significantly enhanced by incorporating reheating in the cycle. In reheat configurations, a first combustor produces steam/CO_2 for a high-pressure steam turbine (HPST), while a second combustor (the "reheat combustor") raises the temperature of the HPST exhaust by burning additional syngas with oxygen. The resulting high-temperature gases then enter an intermediate pressure turbine (IPT) operating at gas turbine conditions.

Grant applications are sought to develop and validate an Oxy-Syngas combustor/gas generator for an intermediate pressure (IP) high temperature (HT) Oxy-Fuel turbine. Approaches of interest must include the development of a reheat combustor that can be incorporated in oxy-syngas plants, which could be commercially deployable by 2015. The specific objectives of the reheat combustor are to raise the temperature of the HPST steam/CO_2 exhaust from 450-600ºC (840-1100ºF) to temperatures as high as 1760ºC (3200ºF), at operating pressures in the range 40-45 bar (600-650 psia). The combustor should be sized for a firing rate of approximately 50 MW_{th}, burning clean syngas from a typical oxygen-blown gasifier, and may resemble a cylinder or "can" gas turbine combustor arranged in a "can-annular" configuration around the inlet of the turbine.

Questions - contact Rondle Harp (rondle.harp@netl.doe.gov)

References:
Subtopic a and b

1 SECA Website. (URL: www.seca.doe.gov)

2 Fuel Cell Handbook, EG&G Services, Parsons, Inc., October 2000. U.S. DOE Contract No. DE-AM26-99FT40575. (Full text available at: http://www.eng.fsu.edu/~kroth/eml%204930/fchandbook.pdf)

Subtopic c and d

1 Hebbar, M.A. et al: Development of Turbo Machinery for a Zero CO_2 Emissions Oxy-Fuel Cycle, Proceedings of 23rd International Pittsburgh Coal Conference, Pittsburgh, PA. September 25-28th, 2006. (For sale at: HTTP://WWW.ENGR.PITT.EDU/PCC/PROCEEDINGSFORMINFO.HTM)

2 MacAdam, S., et al, "Coal-Based Oxy-Fuel System Evaluation and Combustor Development", Proceedings of 32nd International Technical Conference on Coal Utilization and Fuel Systems, Clearwater, FL, June 10-15th, 2007. (Full text available at: http://www.coaltechnologies.com/Program%20Announcement%202007.pdf)

3 Chorpening, B., et al, "Demonstration of a Reheat Combustor for Power Production with CO_2 Sequestration,", Journal of Engineering for Gas Turbines and Power 127, 740 (2005). (Available at: http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=JETPEZ000127000004000740000001&idtype=cvips&gifs=yes)

4 Richards, G.A., et al, "Dilute Oxy-Fuel Combustion Technology for Zero-Emission Power," Proc. Instn. Mech. Engrs, Part A, J. Power and Energy, 219(2), 121 (2005). (URL: http://www.came-gt.com/index.php?option=com_content&task=view&id=14&Itemid=18)

5 O. Colin, et al, "A Thickened Flame Model for Large Eddy Simulations of Turbulent Premixed Combustion", Physics of Fluids, Vol 12, No. 7, July 2000, pp 1843-1863. (Full text: http://scitation.aip.org/getpdf/servlet/GetPDFServlet?filetype=pdf&id=PHFLE6000012000007@webtc.pdf&idtype=tocpdf)

6 Gicquel, L.Y.M., et al, "Velocity Filtered Density Function for Large Eddy Simulation of Turbulent Flows", Physics of Fluids, Vol. 14, No. 3, March 2002, pp. 1196-1213 (Full text: http://scitation.aip.org/getpdf/servlet/GetPDFServlet?filetype=pdf&id=PHFLE6000014000003@webtc.pdf&idtype=tocpdf)

56. INNOVATIONS TO REDUCE ENVIRONMENTAL IMPACT AND INCREASE EFFICIENCY IN COAL POWER PLANTS

The use of coal in energy utilization and conversion systems suffers from a number of considerations with respect to the fuel itself. Coal is a solid fuel containing components that are precursors of environmental pollutants or materials that are potentially damaging to downstream components. Further, coal contains mineral matter that is converted into ash, which can lead to suspended particulates in air, erosion of or deposition in downstream components, and problems of solid waste disposal. This topic seeks to: (1) mitigate the environmental disadvantages of coal utilization, including its potential impact on water quality and availability, through improvements in various aspects of the coal utilization cycle; and (2) increase power plant efficiency by developing advanced sensors and controls for coal power systems, using instrumentation that can withstand the harsh conditions of advanced power generation systems. The research is expected to provide high-quality scientific information on present and emerging environmental issues for use in regulatory and policy decision-making, and to provide measurable benefits in terms of improved efficiencies, lower costs, and new processes.

Grant applications are sought only in the following subtopics:

a. Development of Technologies to Reduce Freshwater Use and Consumption in Coal-Fired Power Plants—Electricity production requires a reliable, abundant, and predictable source of freshwater, a resource

that is limited in many parts of the United States. In particular, the process of thermoelectric generation from fossil fuels requires an average of 25 gallons of water to produce a kWh of electricity, primarily for steam cooling purposes. Power plants also use water for the operation of pollution control devices (such as for flue gas desulfurization technology) as well as for ash handling, wastewater treatment, and wash water. Requiring more than 136 billion gallons of freshwater a day (USGS Circular 1268, 2004), the existing fleet of fossil fuel fired power plants is second only to agriculture (irrigation and livestock) in terms of fresh water use in the United States.

Research directed at water-energy issues is ongoing in the following three areas: (1) non-traditional sources of process and cooling water, (2) innovative water recovery and reuse technology, and (3) advanced cooling technology. Current sponsored research includes, but is not limited to, the analysis of the use of water from abandoned underground coal mines and natural gas and oil produced waters to supply cooling water to power plants; development of membrane separation and scale-inhibitor technologies to enable power plant use of impaired waters; development of a cost-effective liquid-desiccant-based dehumidification technology to recover water from power plant flue gas; investigation of the use of condensing heat exchangers to recover water from boiler flue gas; demonstration of regenerative heat exchange to reduce fresh water use in plants with wet flue gas desulfurization; pilot scale testing of a hybrid cooling technology; evaluation of condensing technology applied to wet evaporative cooling towers; and development of scale-prevention technologies and novel filtration methods. Despite progress made to date, research opportunities still exist for reducing the amount of freshwater required for thermoelectric power plant operations.

Grant applications are sought to develop advanced, cost competitive technologies that result in an overall reduction in freshwater consumption as compared to a pulverized coal-fired power plant equipped with a wet-recirculating cooling tower. This includes, but is not limited to: (1) wet, dry (air cooled), and hybrid wet-dry cooling systems; (2) technologies to recover and reuse water from power plant flue gas; and (3) novel water treatment concepts and approaches to allow the use of non-traditional waters (i.e. mine pool water, coal-bed methane produced water, municipal wastewater) as process water for coal power plants.

Questions - contact Barbara Carney (Barbara.Carney@netl.doe.gov)

b. Novel Technologies for Removal or Stabilization of Mercury and Other Metals Found in Wet FGD System Sulfate-Rich Byproducts—Combustion of coal in electricity generating stations produces coal utilization byproducts from the Flue Gas Desulfurization (FGD) system byproducts. The development and implementation of advanced, wet FGD systems with reduced water requirements may tend to further concentrate these byproducts, particularly mercury and other trace metals, requiring new ways to manage FGD liquor and wastewater quality. Proposed Federal, State, and regional water quality regulations also are driving the need for improvements in the quality of wastewater discharges from FGD systems. Environmental regulatory agencies are considering limits in parts per trillion for metals in liquid discharges to certain water bodies.

The wet FGD system byproducts can contain oxidized water-soluble forms of mercury and other metals (including Al, As, B, Cu, and Se, which are among the top water pollutants identified by the EPA) that are removed from the combustion flue gas. Removal is the preferred form of treatment for metals found in FGD liquid byproducts. Selenium represents a particular challenge, because FGD systems with forced oxidation can oxidize selenium to selenate, which may be more difficult to capture than selenite.

In addition, these flue gas metals absorbed by FGD liquid byproducts may precipitate or otherwise transfer to the solid phase of byproducts. In such instances, the potential exists for these metals to be released from the solid phase to the environment during beneficial use or land filling operations. For example, wet FGD byproducts include sulfite-rich and sulfate-rich material such as synthetic gypsum, which is typically sold for production of wallboard or is land-filled near the power station for future recovery and use. Mercury could be

released from synthetic gypsum to the air at high temperature or under sustained exposure to ultraviolet light. Although leach testing to date has indicated little or no liquid leaching of mercury from synthetic gypsum solids, aggressive leachants interacting with the solid phase could potentially release volatile metals to the air, surface water, or groundwater. This potential could be compounded if power plants switched to higher sulfur coals; then, the resultant fly ash may have higher acidity, which could increase the solubility of cationic metals such as Cu, Ni, and Zn.

There is a need to better understand the characterization of FGD process liquids for a variety of wet FGD configurations, and to develop novel FGD water quality control processes. Therefore, grant applications are sought for the development and bench- or pilot-scale testing of novel technology that will: (1) remove metals from wet FGD liquid and solid sulfate-rich byproducts at the power plant for disposal, or (2) stabilize metals in solid sulfate-rich byproducts to prevent their release during manufacturing, other beneficial use, or landfill operations. Applicants must propose specific project objectives, characterization and testing protocols, and quantified targets for removal or stabilization of mercury and other metals. Characterization of liquid and solid wet FGD byproducts must include sulfate-rich byproducts that are representative of one or more US coal-fired power stations. The test program shall measure removal and/or stability of metals in potential pathways from FGD byproducts to the environment. If a proposed technology for sulfate-rich byproducts also would be effective for other coal utilization byproducts (e.g., fly ash), these benefits should be described in the grant application. Applications involving biological treatment processes, including passive treatment wetlands, will not be considered at this time.

Questions – contact Charles Miller (Charles.Miller@netl.doe.gov)

c. On-Line Solid Fuel Quality Monitoring—Instrumentation and sensors play a key role in describing a process or system. In the case of advanced coal-fired power generation systems, select instrumentation and sensors are not available to provide the data needed to describe or anticipate process changes and to implement novel control algorithms. Therefore, grant applications are sought for the development of online measurement technologies to monitor the quality of coal fuel and other solid feed stocks. Proposed efforts should focus on ability to make measurements on-line and to accurately measure one or more of the following parameters: heating value, mineral content, and trace contaminants. Techniques that are readily adaptable to measure the quality of ash or slag (carbon content, mineral content, etc.) in addition to fuel quality are of high interest.

Questions – contact Susan Maley (susan.maley@netl.doe.gov)

d. Advanced Actuation and Control Technologies for Coal Fired Power Plants—The optimization and control of coal fired power plants is dependent on coordinated and integrated sensing, control, and actuation methodologies used. Prior efforts to develop novel sensing technologies have been successful, but little work and analysis have been devoted to the coordinated control and actuation of processes within a coal fired power plant. As new near-zero-emission plants are designed, significant benefit would be derived from improved hardware to implement process changes and to maintain the tight tolerances that new plants will be required to achieve. Better actuation technologies also would be expected to lead to improvements in the performance of existing coal-fired power plants. Therefore, grant applications are sought for the development of coordinated actuation methodologies and/or hardware to implement a higher degree of precise control over large-scale coal fired power plants (e.g., once-through, super-critical pulverized coal units).

Areas of interest include control valves, dampers, and actuation methodologies for steam side and fuel side control, including downstream emission control. Grant applications must describe the potential value of any particular approach or hardware development. New burner designs are outside the scope of this topic.

Questions – contact Susan Maley (susan.maley@netl.doe.gov)

Subtopic a References:

1 "Water - Energy Interface", Environmental and Water Resources, DOE-NETL. (URL: http://www.netl.doe.gov/technologies/coalpower/ewr/water/index.html)

2 "Estimated Use of Water in the United States in 2000", United States Geological Service (USGS), May 2004. (USGS Circular 1268) (Abstract and full text available at: http://water.usgs.gov/pubs/circ/2004/circ1268/)

3 "Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements", DOE–NETL, August, 2006. (Full text available at: http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/WaterNeedsAnalysisPhaseI1006.pdf)

4 "NETL's Energy-Water RD&D Activities Brochure", DOE-NETL, October 2006. (Brochure available at: http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/water_brochure.pdf)

5 Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water, U.S. DOE, December 2006. (Full text available at: http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/DOE%20energy-water%20nexus%20Report%20to%20Congress%201206.pdf)

6 "Power Plant Water Usage and Loss Study", DOE-NETL, August 2005, Revised August 2007. (Full text available at: http://www.netl.doe.gov/technologies/coalpower/gasification/pubs/pdf/WaterReport_IGCC_Final_August2005.pdf)

Subtopic b References:

1 Mercury Capture and Fate Using Wet FGD at Coal-Fired Power Plants (Full text available at: http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/mercury_%20FGD%20white%20paper%20Final.pdf)

2 Field Testing of a Wet FGD Additive for Enhanced Mercury Control (URL: http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/wet-fgd.html)

3 Characterization of Coal Combustion By-Products for Mercury (URL: http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/enviro/consol.html)

4 Fate of Mercury in Synthetic Gypsum Used for Wallboard Production (URl: http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/enviro/gypsum.html)

5 Commercial Use of Coal Utilization By-Products and Technology Trends (Full text available at: http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/coal_util.pdf)

6 The University of North Dakota Energy and Environmental Research Center www.undeerc.org and Electric Power Research Institute www.epri.com websites may contain additional reference information on byproduct characterization and the fate of mercury and other metals.

Subtopic c and d References:

1 Descriptions of the advanced power systems can be found on the National Energy Technology Laboratory's (NETL) Website. (URL: http://www.netl.doe.gov/)

Workshop Proceedings: 2006 Advanced Process Control Workshop, 2002 NETL Sensor and Control Program Portfolio Review and Road mapping Workshop, 2001 Sensor and Control Workshop (URL: http://www.netl.doe.gov/technologies/coalpower/advresearch/ref-shelf.html

57. COAL GASIFICATION AND COMBUSTION TECHNOLOGIES

Coal gasification offers a versatile and clean way to convert the energy content of coal into electricity, hydrogen, and other high quality transportation fuels, as well as into high-value chemicals to meet specific market needs. Most importantly, in a time of electricity and fuel price spikes, flexible gasification systems can provide a capability to operate on low-cost, widely-available feedstocks. Furthermore, gasification may be one of the best ways to produce clean liquid fuels from coal, and clean-burning hydrogen for tomorrow's automobiles and power-generating fuel cells. Hydrogen and other coal-derived gases also can be used to fuel power-generating turbines or used as chemical "building blocks" for a wide range of commercial products. The DOE Office of Fossil Energy is working on coal gasifier technology advances that enhance efficiency, environmental performance, and reliability.

Grant applications are sought only for the following subtopics:

a. Novel Concepts in Industrial Gasification—Natural gas is used as a feedstock in many industries in addition to the power production industry. However, the increasing cost of natural gas, along with the likelihood that the cost will continue to increase, is driving the development of new technologies to improve the economic return for coal gasification processes outside that of power production. Therefore, grant applications are sought to develop novel gasification technologies to produce synthesis gas or substitute natural gas from (1) coal or (2) a coal/biomass blend (up to 50% biomass on a thermal basis). Proposed approaches must produce the gas in combination with power at a scale of 50 to 100 MWe, with the preference being on coal/biomass blends.

Questions – contact Ronald W. Breault (ronald.breault@netl.doe.gov)

b. Hydrogen Production and Process Intensification—The DOE's FutureGen project, now in its early planning stage, aims to demonstrate the technical/economical feasibility of a coal gasification plant to produce power with near-zero emissions, including the emission of carbon dioxide. The strategy is to convert coal to hydrogen that would be used as fuel for fuel cells and/or gas turbines, with the concurrent sequestering of the concentrated carbon dioxide from the processing and power blocks. Under this scheme, coal first would be gasified to produce synthesis gas (mainly hydrogen and carbon monoxide), and then processes for removing impurities and for improving hydrogen yield through the water-gas-shift reaction would follow. Finally, the hydrogen would be separated from other compounds. The efficiency of this coal-to-hydrogen process could be enhanced if the downstream steps of raw syngas purification, water-gas-shift and hydrogen separation were combined into a single step, carried out at temperatures compatible with the synthesis gas that exits from the cleanup step (350^{o}C to 400^{o}C)

Grant applications are sought to develop new hydrogen separation/purification concepts, which can operate in the preferred 350^{o}C to 400^{o}C range, as a first step in the development of a combined purification, water-gas-

shift and hydrogen separation reactor. Proposed approaches should provide robust performance; high hydrogen throughput, selectivity, and recovery; long system life; and low operating cost. These new technologies should be able to operate at pressures compatible with advanced gasifier pressures (500 up to 1000 psig). In addition, they should have high tolerance for contaminants such as sulfur, chlorine, and the other trace gas species found to be present in raw gasifier syngases. Grant applications should demonstrate familiarity with current commercial technologies for producing hydrogen from coal, as well as with the ongoing R&D supported by DOE in the coal-to-hydrogen program.

Grant applications also are sought to develop improved hydrogen separation concepts for next generation power systems. Areas of interest include membranes and/or other concepts, such as regenerable adsorbents for the recovery of hydrogen from coal gasification streams. Proposed concepts should achieve the following targets: (1) a small footprint or high flux rate (for membranes); (2) low cost; (3) improved durability and resistance to contaminants; (4) low parasitic power requirements; and (5) low separation device fabrication costs.

Questions - contact Donald Krastman (donald.krastman@netl.doe.gov)

Subtopic a References:

1 "Gasification – Advanced Gas Separation: O2 Separation," U.S. DOE National Energy Technology Laboratory Website. (URL: http://www.netl.doe.gov/technologies/coalpower/gasification/gas-sep/index.html)

2 "ITM Oxygen: The New Oxygen Supply for the New IGCC Market," Air Products, 2005 Gasification Technology Council presentation. (URL: http://www.gasification.org/Docs/2005_Papers/43ARMS.pdf)

Subtopic b References:

1 Lin, Y. S., "Microporous and Dense Inorganic Membranes: Current Status and Prospective," *Separation and Purification Technology*, 25:39–55, 2001. (Abstract and ordering information available at http://www.sciencedirect.com/. On menu at left, Browse by [journal] title for volume and page number.)

2 " FutureGen – Tomorrow's Pollution-Free Power Plant," U.S. DOE Office of Fossil Energy Website. (URL: http://www.fossil.energy.gov/programs/powersystems/futuregen/index.html)

3 "Hydrogen and Clean Fuels Research," U.S.DOE Office of Fossil Energy Website. (URL: http://www.fe.doe.gov/programs/fuels/index.html)

4 Tong, J., et al., "Thin Defect-Free Pd Membrane Deposited on Asymmetric Porous Stainless Steel Substrates," *Industrial & Engineering Chemistry Research*, 44(21): 8025 -8032, October 2005. (ISSN: 0888-5885) (Abstract and ordering information available at: http://sciserver.lanl.gov/cgi-bin/sciserv.pl?collection=journals&journal=08885885&issue=v44i0021. Scroll down to title and click on "Abstract". To purchase, click on link in upper right corner.)

5 Kamakoti, P., et al., "Prediction of H_2 Flux thru Sulfur-Tolerant Dense Binary Alloy Membranes," Science Magazine, Vol. 307, January 28, 2005. (Abstract and ordering information available at: http://www.sciencemag.org/cgi/search?src=hw&site_area=sci&fulltext=Prediction+of+H2+Flux+thru+Sulfur-Tolerant+Dense+Binary+Alloy+Membranes+Volume+307&search_submit.x=9&search_submit.y=5)

6 Doong, S., et al., "A Novel Membrane Reactor for Direct Hydrogen Production from Coal," DOE Technical Report, January 2006. (OSTI ID: 876470) (Full text available at: http://www.osti.gov/bridge/product.biblio.jsp?query_id=0&page=0&osti_id=876470)

7 Milliken, J., "DOE Hydrogen Program: 2006 Annual Merit Review and Peer Evaluation Report" DOE Technical Report, September 2006. (OSTI ID: 896398)(Full text available at: http://www.osti.gov/bridge/product.biblio.jsp?query_id=1&page=0&osti_id=896398)

8 "H2-from-Coal Multi-Year Program Plan," U.S.DOE National Energy Technology Website (URL: http://www.netl.doe.gov/technologies/hydrogen_clean_fuels/refshelf/pubs/External_H2_from_Coal_RDD_Plan_September_13.pdf)

9 Balachandran, U., "Hydrogen Separation Membranes Annual Report for FY2006," DOE Technical Report, January 2007. (OSTI ID: 899332) (Full text available at: http://www.osti.gov/bridge/product.biblio.jsp?osti_id=899332)

58. HIGH PERFORMANCE MATERIALS FOR LONG TERM FOSSIL ENERGY APPLICATIONS

New materials, ideas, and concepts are required to significantly improve performance and reduce the costs of existing fossil systems or to enable the development of new systems and capabilities. The Fossil Energy Materials Program conducts research and development on high-performance materials for longer-term fossil energy applications, including gas separations and storage. The program is concerned with operation in the hostile conditions created when fossil fuels are converted to energy. These conditions include high temperatures, elevated pressures, and corrosive environments (reducing conditions, gaseous alkali).

Grant applications are sought only for the following subtopics:

a. Surface Modification of Alloys for Ultrasupercritical Coal-Fired Boilers—The implementation of ultrasupercritical boilers will require materials with high-temperature creep properties and high-temperature oxidation and corrosion resistance. New ferritic, austenitic, and nickel-based alloys have been designed to meet the creep resistance demands, but the high operating temperature poses the risk of accelerated material degradation in various harsh environments. In a coal-fired boiler, oxidizing and corroding environments range from simple gas attack to deposition microclimates of a highly complex nature. The gases can be oxidizing mixtures, such as mixtures of O_2 and SO_2/SO_3, or more complex mixtures that include aggressive gaseous compounds such as H_2S, HCl, COS, CS_2, CO, and methyl mercaptan. These latter gaseous compounds are usually generated during the substoichiometric combustion of coals when modified combustion systems are implemented for NOx emissions control. In addition, the substoichiometric combustion process generates unburned carbon and pyritic particulates that, depending on the hydrodynamics of the fireball, may end up deposited on heat transfer surfaces. These deposits can generate various local reducing environments, ranging from carbonaceous to sulfidizing, and even low-melting eutectics that act as a flux on the metal surface.

Surface modification techniques could provide an alternative to the use of costly nickel-based materials. For example, thermal spray technology has evolved in the last 15 years with the implementation of techniques, such as High Velocity OxyFuel (HVOF), that have improved the quality of the applied coatings. Other emerging techniques include cold spray technology, which when combined with nano-size powders can provide flexibility and economic advantages, and weld overlay and chromizing technologies, which are used to ensure that pressure parts are adequately protected from the operating environment.

Grant applications are sought to optimize the techniques mentioned above, or to develop entirely new surface modification techniques, for the protection of high temperature alloys used in ultrasupercritical coal-fired boilers.

Questions - contact Patricia Rawls (patricia.rawls@netl.doe.gov)

b. Steam-Side Corrosion Of Ultrasupercritical (USC) Boiler And Turbine Materials—One of the DOE's major programmatic goals is to design and use ultrasupercrital (USC) steam in next generation boilers and steam turbines, which would lead to increases in thermal efficiencies and decreased emissions of air pollutants such as SO_x, NO_x, and CO_2. Ultrasupercritical steam operations are considered to be those that operate in the range from 565°C/24MPa (1050°F/3400 psi) to 760°C/35MPa (1400°F/5000 psi). Although a number of heat resistant steels (9%-12% Cr) have been developed to withstand USC conditions around 630°C, it has been shown that ferritic/martensitic steels are preferred for heavy thick-walled components, because of their lower coefficient of thermal expansion (CTE) as compared to austenitic steels. The USC Consortium, sponsored by DOE-NETL, has identified a number of potential alloy candidates for use in advanced USC cycles, particularly as related to fire-side corrosion and creep resistance. However, little, if any, data has been generated at actual USC steam temperatures and operating pressures, as needed to identify steam-side corrosion mechanisms, kinetic rates of corrosion, internal metal losses, etc. There is also concern that potential damage may result to steam turbine blades resulting from exfoliation of the internal oxide scale.

Grant applications are sought for technologies, processes, and innovative methods that directly address the issues listed above. Approaches of interest must include the conduct of experiments at USC operating conditions with candidate alloys defined by the USC Consortium, including T122, T92, Super 304H, Save 25, HR3C, IN740, Haynes 230, and CCA 617. Of particular interest are grant applications that demonstrate a coordination of efforts with the USC Consortium and a strong diverse team that includes representatives from universities, National Labs, or industrial partners. Grant applications related to studies of the fire-side corrosion of these materials are not of interest and will be declined.

Questions - contact Patricia Rawls (patricia.rawls@netl.doe.gov)

Subtopic a References:

1 Stringer, J., "Coatings in the Electric Supply Industry: Past, Present and Opportunities for the Future," *Surface and Coatings Technology*, 108-109: 1-9, 1998. (ISSN: 0257-8972)

2 Pint, B. A., et al., "Defining Failure Criteria for Extended Lifetime Metallic Coatings," 2002. (Full text available at: http://www.netl.doe.gov/publications/proceedings/02/materials/Pint%20Fossil%20Paper.pdf)

3 Pint, B. A., et al., "High Temperature Oxidation Performance of Aluminide Coatings," 2003. (Full text available at: http://www.ornl.gov/sci/fossil/Publications/ANNUAL-2003/ORNL-2B.pdf)

4 Zhang, Y., et al., "Interdiffusion Behavior in Aluminide Coatings for Power Generation Applications," 2003. (Full text available at: http://www.netl.doe.gov/publications/proceedings/03/materials/manuscripts/Zhang_m.pdf)

Subtopic b References:

1 Holcomb, G., et al, "Ultra-Supercritical Steam Corrosion," (Full text available at: http://www.osti.gov/bridge/purl.cover.jsp?purl=/835699-QqFxB5/native/)

2 Blum, R. and Hald, J. (2002) "Benefit of Advanced Steam Power Plants," in *Proceedings of the 7th Liège Conference Materials for Advanced Power Engineering*, European Commission and Universite de Liège. (Full text available at: http://www.asma.ulg.ac.be/info.pdf)

3 Dogan, C. P. and Wright, I. G. (2003) "Materials for Ultra-Supercritical Steam Turbines," 28th International Technical Conference on Coal Utilization and Fuel Systems, Clearwater, FL, March 10-13. (Full text available at: http://www.cesweb.livedpi.com/mediakit/CES%20Clearwater%20Paper%202004.doc)

4 Kishimoto, M, Minami, Y., Takayanagi, K., and Umaya, M. (1994) "Operating Experience of Large Ultra Super Critical Steam Turbine with Latest Technology," in Advances in Steam Turbine Technology for the Power Industry, PWR-Vol. 26, American Society of Mechanical Engineers, New York, NY, pp. 43-47. (ISBN 0-7918-13827) (URL: http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=82726)

5 Rao, U. S. (2001) "DOE Launches Project to Improve Materials for Supercritical Coal Plants," Techline, October 16, 2001 (URL: www.netl.doe.gov)

6 Viswanathan, R. and Bakker, W. T. (2001) "Materials for Ultra Supercritical Coal Power Plants," *Journal of Materials Engineering and Performance*, Vol. 10, Number 1, pp. 81-95. (ISSN-1059-9495)

59. CLIMATE CONTROL TECHNOLOGY FOR FOSSIL ENERGY APPLICATIONS

This topic addresses carbon dioxide (CO_2) and other non-CO_2 greenhouse gases, principally methane (CH_4), which are natural and important components of the atmosphere. Together with water vapor, these gases exert a "greenhouse" effect, trapping heat within the Earth's atmosphere. This phenomenon has, thus far, maintained the planet's temperate climate. However, because CO_2 is generated by the combustion of all carbon-based fuels, human activity has raised global emissions of CO_2 and other non-CO_2 greenhouse gases from a negligible level two centuries ago to significant amounts today. It has been postulated by some in the scientific community that the current rate of greenhouse gas build-up in the atmosphere worldwide contributes to global warming, which could put the global climate out of balance and thus cause significant adverse consequences for human health and welfare. Hence, the capture and permanent sequestration of CO_2, as well as other non-CO_2 greenhouse gases (GHG), has become a major worldwide goal. In the United States, the capture and sequestration of CO_2 and other non-CO_2 GHG is expected to be an important element of any strategy to reduce the emission of GHG to the atmosphere.

Grant applications are sought only in the following subtopics:

a. Advanced Separation And Capture Techniques For CO_2 Produced By 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 technologies that can substantially lower the cost of CO_2 capture from flue gas produced by existing coal-fired power plants. Approaches of interest include new methods to improve the performance and lower the costs associated with solvent and sorbent based CO_2 capture technologies. Proposed technologies must: (1) demonstrate an ability to perform with actual flue gas compositions generated from existing coal-fired power plants; (2) be capable of 90% or greater reduction in CO2 emissions per net kWh; and (3) result in less than a 20% increase in the cost of energy service. Grant applications should demonstrate familiarity with both current commercial technologies and ongoing research, and include systems and economic

analyses in accordance with the National Energy Technology Laboratory's Carbon Capture and Sequestration Systems Analysis Guidelines (http://www.netl.doe.gov/coal/Carbon%20Sequestration/pubs/CO2CaptureGuidelines.pdf).
Grant applications dealing with membrane-based systems, with oxycombustion technologies, or with incremental improvements to amine-based systems are not of interest and will be declined..

Questions - contact Timothy Fout (timothy.fout@netl.doe.gov)

b. Advanced Monitoring Technologies for Geologic CO2 Sequestration—Monitoring, mitigation, and verification (MM&V) is defined as the capability to: (1) measure the amount of CO_2 stored at a specific sequestration site, (2) monitor the site for leaks or other deterioration of storage integrity over time, and (3) verify that the CO_2 is stored in a way that is permanent. Grant applications are sought for technologies that characterize a formation and its overlying burden as a suitable sink and identify potential leakage points. Of particular interest are technologies that can monitor the fate of CO_2 within geologic formations that will be used as potential sinks, determine the integrity of the cap rock, identify leakage pathways, and monitor the migration of CO_2 through the existing overburden to potential drinking water sources.

Approaches of interest include, but are not limited to advancements in surface-to-borehole seismic, micro-seismic, cross-well electromagnetic, electrical resistance tomography, water chemistry, passive pressure, and seismic sensors. Also of interest are advances in technologies to automate the interpretation of the results from these measurement technologies, in order to speed decision making, conduct multivariate analysis, and/or interpret the response from the technologies that characterize the phase of CO_2 and leakage points.

Questions – contact Darin Damiani (darin.damiani@netl.doe.gov)

Subtopic a Reference:

1 Carbon Capture and Sequestration Systems Analysis Guidelines, U.S. DOE NETL, April 2005) (Full text available at: http://www.netl.doe.gov/technologies/carbon_seq/Resources/Analysis/pubs/CO2CaptureGuidelines.pdf)

2 *Carbon Sequestration Technology Roadmap and Program Plan – 2007*, U.S. DOE National Energy Technology Laboratory (NETL), May 2007. (Full-text available at: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/2007/2007Roadmap.pdf)

3 U.S. DOE NETL *Carbon Sequestration – Core R&D: CO2 Capture* Web page. (URL: http://www.netl.doe.gov/technologies/carbon_seq/core_rd/co2capture.html)

Subtopic b Reference:

1 "Carbon Capture and Sequestration Systems Analysis Guidelines – 2005," U.S. DOE National Energy Technology Laboratory (NETL), April 2005. (Full-text available at: http://www.netl.doe.gov/technologies/carbon_seq/Resources/Analysis/pubs/CO2CaptureGuidelines.pdf)

2 Vine, E. and Sathaye, J., "The Monitoring, Evaluation, Reporting, and Verification of Climate Change Mitigation Projects: Discussion of Issues and Methodologies and Review of Existing Protocols and Guidelines," prepared for U.S. Environmental Protection Agency, Berkeley, CA: Lawrence Berkeley National Laboratory, December 1997. (Full text available at:

http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsReferenceMERVCReportMethods.html)

3 Carbon Sequestration Leadership Forum, "Final Report from the Task Force for Identifying Gaps in Monitoring and Verification of Geologic CO_2 Storage" prepared for the Executive Committee of the International Energy Agency GHG Programme, November 2006. (Full text available at: http://www.cslforum.org/documents.htm)

60. ENHANCED OIL RECOVERY, OIL SHALE, OIL AND NATURAL GAS TECHNOLOGIES

Much of the known reserves of oil in the U.S. cannot be recovered by conventional means, and advanced technologies will be required for extraction. Therefore, the DOE seeks innovative methods and concepts that will contribute to more efficient and economic processes for the recovery and utilization of unrecovered oil and oil shale. For oil shale, new technology is needed to cleanly extract and treat the organic material, and to address spent shale. This topic supports innovative research that supplements and complements, but does not duplicate or displace, private and other public research and development efforts. Grant applications must propose a concept development effort and a work plan (including partnership arrangements, if any) to pursue the idea into a workable system.

Grant applications are sought only in the following subtopics:

a. CO_2 Flooding For the Recovery of Oil—CO_2 flooding, the injection of carbon dioxide into existing oil fields, has been shown to improve oil recovery. However, existing methods require improvements with respect to sweep efficiency, reservoir management, and asphaltene dropout. In order to prolong the sustainability of the oil supply over the longer-term and to aid in the sequestration of carbon for the environment, dramatic improvements to carbon dioxide flooding are required. Grant applications are sought to develop: (1) chemicals or methods to improve sweep efficiency; (2) methods to monitor the CO_2 flood front for better reservoir management; and (3) chemicals or methods to inhibit asphaltene dropout during CO_2 flooding. All grant applications must lead to cost-effective ways to improve CO_2 flooding.

Questions – contact Jesse Garcia (Jesse.Garcia@netl.doe.gov)

b. Oil Shale Development—The U.S. also has billions of barrels of oil shale. (The "shale" is usually a relatively hard rock.) In 2004, U.S. DOE published two summaries of The Strategic Significance of America's Oil Shale Resource (Volume I, Assessment of Strategic Issues, and Volume II, Oil Shale Resource Technology and Economics), which summarize the world's oil shale industry and its challenges.

The production of liquids from oil shale kerogen, the organic material in oil shale, via surface retorting has been shown to be technically and economically viable, but many challenges remain. Grant applications are sought to develop cost-effective, environmentally-low-impact separation/extraction processes to extract kerogen with high yield. Proposed process should have very low fines carryover into the organic phase and should leave clean "spent shale" that rapidly dewaters, thus permitting rapid re-vegetation of mined areas (in months rather than decades). Also, the system should not leave hot molten spent shale for surface disposal.

If an organic/gaseous-based surface extraction system (super-critical extraction) is used, the organic phase must be free of fines, and the processed shale must rapidly consolidate and have low organics carryover. Also, if the extraction system yields a fines-free organic phase, the processed shale must rapidly consolidate with a low organics carryover.

Grant applications also are sought to develop processes for the economic and environmentally benign use of spent shale from the Green River Formation (either hot shale directly from a retort or previously processed shale) in commercial products, including building and roadway materials. Approaches of interest would use the spent shale along with other resources of the area, and also would use minimal energy and water as part of the process. Grant applications must account for the chemical composition of the shale and the processing conditions of the retort (temperature, pressure and time), all of which affect the starting material for these future commercial products. Human health and environmental impacts also must be considered.

Questions – contact Jesse Garcia (Jesse.Garcia@netl.doe.gov)

Subtopic a References:

1 Justice, Jim, et al., "Interwell Seismic for Reservoir Characterization and Monitoring," SPE/DOE Improved Oil Recovery Conference, Tulsa , OK, April (SPE Paper 62588) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

2 Wagener, D. C. and Harpole, K. J., "Determination of Relative Permeability and Trapped Gas Saturation for Predictions of WAG Performance in the South Cowden Unit CO2 Flood," presented at the 1996 SPE/DOE Tenth Symposium on Improved Oil Recovery, Tulsa , OK, April 21-24, 1996 . (SPE Paper 35429) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

3 Tsau, Y. S. and Heller, J. P., "How Can Selective Mobility Reduction of CO2-Foam Assist in Reservoir Floods?" presented at the 1996 Permian Basin Oil and Recovery Conference, Midland , TX, March 27-29, 1996 . (SPE Paper 35168) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

4 Yaghoobi, H. and Heller, J. P., "Effect of Capillary Contact on CO2-Foam Mobility in Heterogeneous Core Samples," presented at the 1996 Permian Basin Oil and Recovery Conference, Midland, TX, March 27-29, 1996. (SPE Paper 35169) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

5 Yaghoobi, H. and Heller, J. P., "Improving CO2 in Heterogeneous Media," presented at the 1996 SPE/DOE Tenth Symposium on Improved Oil Recovery, Tulsa, OK, April 21-24, 1996. (SPE Paper 35403) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

6 Hallenbeck, L. D., et al., "Design and Implementation of a CO2 Flood Utilizing Advanced Reservoir Characterization and Horizontal Injection Wells in a Shallow Shelf Carbonate Approaching Waterflood Depletion," pp. 26-27, May (NTIS Order No. DE96001234) (Abstract and ordering information available from National Technical Information Service (NTIS. Telephone: 1-800-553-6847. Website: http://www.ntis.gov/ Search by order no. Please note: Items that are unavailable via the Website might be obtained by phoning NTIS.)

7 Michels, M., et al., "Enhanced Water Flooding Design Using Diluted Surfactant Concentrations for North Sea Conditions," presented at the 1996 SPE/DOE Tenth Symposium on Improved Oil Recovery, Tulsa, OK, April 21-24, 1996 . (SPE Paper 35372) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

8 Yin, Y. R, et al., "Asphaltene Inhibitior Evaluation in CO2 Floods: Laboratory Study and Field Testing," presented at 2000 SPE Permian Basin Oil and Gas Recovery Conference, Midland, TX, March 21-23, 2000. (SPE Paper 59706) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

9 Leontaritis, K.J. and Mansoori, G. A., "Asphaltene Deposition: A Survey of Field Experiences and Research Approaches," *Journal of Petroleum Science and Engineering*, 1(3): 229-239, August 1988. (Abstract and ordering information available at: http://sciencedirect.com. In center of page under "Search for a title", search for journal, and use information above to locate article.)

10 Leontaritis, K.J., et al., "A Systematic Approach for the Prevention and Treatment of Formation Damage Caused by Asphaltene Deposition," Production and Facilities, 9(3): 157-164, August 1994. (SPE Paper 23810) (Paper preview and ordering information available at: http://www.spe.org/elibrary)

Subtopic b References:

1 *Survey of Energy Resources: Oil Shale,* World Energy Council, (URL: http://www.ecology.com/archived-links/oil-shale/index.html)

2 Sinor, J. E., *Oil Shale Experience*, from J. E. Sinor's personal library, University of Kentucky, undated. (Available at: http://edj.net/sinor/qshaleexp.html)

3 International Center for Heavy Hydrocarbons, Library (URL: www.oildrop.org)

4 Campbell, J. H.: "The Kinetics of Decomposition of Colorado Oil Shale: II Carbonate Minerals." Lawrence Livermore National Laboratory, UCRL-52089, Livermore CA Part 2 pp. 53, 1978. (Available at: http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=6869479)

5 Mallon, Richard G., "Preparation and Injection of Grout from Spent Shale for Stabilization of Abandoned In-situ Oil Shale Retorts." Society of Petroleum Engineers paper 8448, July 1982. (Available at: http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=6727404)

6 Russell, P.L.: "Oil Shales of the World: Their Origin, Occurrence and Exploitation." Pergamon Press, New York, New York, 1990. (Full text available at: http://www.elsevier.com/wps/find/bookdescription.librarians/27745/description#description)

7 18. Yen, T. F. and Chilingarian, G.V. (eds): "Oil Shale." Elsevier, Amsterdam, 292pp. 1976. (URL: http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7309409)

8 Johnson, H. R., P. M. Crawford and J. W. Bunger: "Strategic Significance of America's Oil Shale Resource, Vol. I, Assessment of Strategic Issues." U.S. DOE Office of Naval Oil Petroleum and Oil Shale Reserves, Washington, DC., March 2004. (Full text available at: http://www.fossil.energy.gov/programs/reserves/npr/publications/npr_strategic_significancev1.pdf)

9 Johnson, H. R., P. M. Crawford and J. W. Bunger: "Strategic Significance of America's Oil Shale Resource, Vol. II, Oil Shale Resources Technology and Economics." U.S. DOE Office of Naval Oil Petroleum and Oil Shale Reserves, Washington, DC., March 2004. (Full text available at: http://fossil.energy.gov/programs/reserves/npr/publications/npr_strategic_significancev2.pdf)