U.S. Department of Energy

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

FY 2009
Technical Topic Descriptions

FOR REFERENCE ONLY

The funding opportunity associated with these topics is closed.

OFFICE OF BASIC ENERGY SCIENCES

1. TECHNOLOGY TO SUPPORT BES USER FACILITIES

The Office of Basic Energy Sciences (BES), within the DOE's Office of Science, is responsible for 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. Synchrotron 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 and/or high frame rate imaging detectors; (5) detectors for high rate fluorescence spectroscopy; and (6) detectors for high energy fluorescence spectroscopy.

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 3$_{rd}$ generation light sources. Grant applications are sought to develop monitors for beam position and electron bunch length. The beam position monitor should have nanometer 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 diagnostic 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 noninvasive 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-breakup 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:

- 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.

- 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.

- 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.

- Alternative and innovative concepts for damage mitigation**,** aside from small gas bubbles or protective gas walls. Grant applications 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)

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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.osti.gov/bridge/servlets/purl/787153-XUP8Mj/native/787153.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://scitation.aip.org/proceedings/confproceed/705.jsp

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.)

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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)

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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)

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2. "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. "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)

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2. RADIO FREQUENCY (RF) DEVICES AND COMPONENTS FOR ACCELERATOR FACILITIES

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future synchrotron radiation light source, free electron lasers, and spallation neutron source user facilities. This topic seeks the development of radio frequency devices and components to support these user facilities. **Grant applications are sought only in the following subtopics.**

a. Power Devices and Components for High Level Radio Frequency (RF) Accelerator Systems—Grant applications are sought to develop 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.

Grant applications also are sought to develop (1) 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; (2) higher power Insulated Gate Bipolar Transistor (IGBT) technology. IGBTs with > 6000Volts, >2000Amps are required for development of high power modulators and power supplies; (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) a 2.815GHz CW klystron (~100kW), possibly with two output windows, that would be suitable for a superconducting (SC) rf cavity; (5)a moderate power (10-50kW CW) tetrode cavity, tunable from 340-360MHz (or possibly more) – such a cavity would make tetrodes or diacrodes competitive for sockets in SC cavity applications; (6) a very high power (100-400 kW) 350-500 MHz solid state power amplifier to replace klystron amplifiers in synchrotron light sources; (7) 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; (8) 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, and factor-of-10 variable coupling with minimum transverse kick to the beam; and (9) an adjustable 20-way 40 kW CW power combiner operating at 352 MHz..

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

b. Modulators for High Level Radio Frequency (RF) Accelerator Systems—Grant applications are sought to develop 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. Grant applications also are sought to develop (1) a 1KHz. 300 kV, 300A solid-state modulator for production of picosecond X-ray pulses using RF deflecting cavities; and (2) a robust, high-average-power (200kW) 1kHz modulator system that operates at about 300 kV, 300 A with ultimate rep rate at 1kHz or higher.

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

c. Low Level Radio Frequency (LLRF) Accelerator Systems—Grant applications are sought to develop 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.

Grant applications also are sought to develop 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.

Finally, grant applications are sought to develop a user-friendly, multi-channel "all in one" time-stamp diagnostic instrument that can accept baseband 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.

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

d. Devices for the Manipulation of Electron Beams—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.

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

Subtopic a 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)

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3. ADVANCED SOURCES FOR ACCELERATOR FACILITIES

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future synchrotron radiation light source, free electron laser, and spallation neutron source user facilities. This topic seeks the development of technology to support the particle and radiation sources needed for these user facilities. **Grant applications are sought only in the following subtopics.**

a. Electron Gun Technology—Grant applications are sought to develop novel electron gun features including:

(1) Robust cathode 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-rad, 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) 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.

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

b. High Brightness Sources of Negative Hydrogen Ions—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 π mm·mrad, or about 100 mA, with a normalized emittance of 0.35 π mm·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 meantime-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).

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

c. Undulator Radiation Sources—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 10 watts per meter of undulator length. Novel ideas for SCU design, construction, and thermal management are needed to meet these challenging requirements.

(2) Cryogenically-Cooled Permanent Magnet Undulators (CPMUs). When permanent magnet materials are cooled to low temperatures they exhibit a larger coercivity (5-10%) for convenetional materials like NdFeB or CoSm, and up to 20% for more exotic materials. To make use of this effect, undulators must be cooled to cryogenic termperatures and in the cooled down stage, magnetic measurements and adjustments of the PM must be .performed. This requires a complex design.

(3) High coercivity permanent magnet materials for CPMUs. To take full advantage of CPMUs sintering and manufacturing procedures need to be developed for permanent magnet material like PrFeB, which exhibits large increases in coercivity at cryogenic temperatures.

(4) New superconducting materials for undulator applications. Three types of materials promise a considerable enhancement of undulator performance:

- High temperature superconducting materials such as YBCO which operate at about 90K would allow current densities up 100kA/mm^2. The challenge here is to optimize the conductor design to maximize the current density and the transport current. A next step would lead to the development of the coil manufacturing techniques based on such materials.

- Thin film high temperature superconducting materials such as MgB2 which are operated at ~39K may become a good material for undulator magnets as the mechanical properties will be determined by the substrate material. The issue is the production of the thin films and the choice of optimum substrate materials.

- APC (artificially enhanced pinning center) NbTi Superconductor which would allow super-high current densities exceeding the Jc of conventional NbTi superconductor by a large factor (14 kA/mm^2 @ 2 T). The high current density might offer in particular an advantage for design magnet coils for undulator magnets.

(5) 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)

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2. Proceedings of the Future Light Source Workshop (FLS2006), Hamburg, Germany, May 2006. (Full text
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.1. Stockli, M., "The Development of High-Current and High Duty-Factor H- Injectors," presented at
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4. ANCILLARY TECHNOLOGIES FOR ACCELERATOR FACILITIES

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future synchrotron radiation light source, free electron laser, and spallation neutron source user facilities. This topic seeks the development of computational, control, and superconducting technologies to support these user facilities. **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.

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.

Finally, grant applications are sought to develop large-scale timing and synchronization systems for next generation light sources, with timing stability requirements extending from ~100 fs to 1 femtosecond or less. For example, these requirements include the need to enable the synchronization of multiple radio frequency components and laser systems, over distances of the scale of km, in advanced accelerators and free electron lasers. This precision in timing must be maintained over periods of time on the order of 24 hours.

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

b. Superconducting Technology for Accelerators—Superconducting HOM-damped (higher-order-mode-damped) RF systems are needed for present and future storage ring and linac applications. Grant applications are sought to develop:

(1) A high gradient (15-50 MVm^{-1}) 750MHz superconducting cavity for linac-driven synchrotron radiation sources. The cavity should operate in CW mode with high efficiency of wall-plug-to-beam-power conversion. Systems should be capable of supporting a beam current up to 500 mA, with parasitic mode Q-values below 1000, and minimal short-range wakefields.

(2) A 1500 MHz passive superconducting Landau cavity for storage-ring bunch lengthening.

(3) A superconducting RF power coupler capable of handling 500 kW CW RF power.

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

c. Cooling of Superconducting Systems—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.

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.

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

d. Advanced Laser Systems for Accelerator Applications—Advanced laser systems are needed for photoinjectors, for Free-Electron Laser Seeding or for current-enhanced self-amplified spontaneous emission (ESASE), for laser-ion stripping of hydrogen beams, and for laser wire beam profile measurements in proton particle accelerators. Grant applications are sought for the development of:

(1) 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.

(2) Laser pulse shaping systems that can modify the laser pulse in 3D, in order to minimize the emittance growth due to space charge effect in a photoinjector. Approaches of interest can include pulse stacking, laser phase modulation, and others. In general, the pulse should have a homogeneous intensity distribution (10% modulation) confined in a sharp boundary in 3D, with either a cylindrical or ellipsoidal geometry.

(3) A mid-IR, carrier envelope phase (CEP) stabilized laser with tens of mJs of energy and a few carrier cycles within a FWHM of 10-50 fs.

(4) A mid-IR (2.0 micron) laser for E-SASE, with a pulse under 100fs, possibly CEP-stabilized in the few mJ energy range.

(5) Tunable lasers to be used as seeds for free electron lasers (FELs). The central wavelength should be within the range of 10-50 nm, and continuously tunable within a 20% or greater band within that wavelength range. Pulse duration should be adjustable and on order of 100 fs. Peak power within the pulse should be on order of 100 kW. Optical pulses should be reproducible on a shot-to-shot basis, with good temporal coherence within the pulse, good beam quality ($M^2<1.3$), and a repetition rate of 100 kHz or greater.

(6) Lasers for laser-ion stripping of hydrogen beams with the following features: high repetition rate (~400 MHz), high peak power (~1MW), picosecond 355 nm pulses to match the SNS linac in-beam structure (50 ps long micropulses separated by 2.5 ns and gated into minpulses of 650 ns repeating at 1.058 MHz and bunched into 1 ms macropulses).

(7) Laser power-recycling cavity at 355 nm to reduce average laser power requirements for ion stripping. Important design criteria include compactness, length to match bunch repetition rate and stabilized to small fraction of wavelength, protection of mirrors from electron and gamma radiation, and in vacuum design.

(8) Lasers for laser-wire-beam profile measurements with the following specifications:

- pulse energy of 100 mJ at 1064 nm;
- repetition rates of 30 or 60 Hz with external trigger;
- compact laser head with dimension of about 6'x3"x3";
- no chilled water required;
- power supply remotely controllable through Ethernet cables; and
- radiation resistance for doses greated than 10^6 rads.

Based on previous experiments, key components in the radiation-resistant laser system are the YAG crystal, fold prism, cube polarized in the laser head, and IC chips in the laser controller unit.

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

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5. INSTRUMENTATION FOR ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY

The Department of Energy supports research and facilities in electron and scanning probe microscopy for the characterization of materials. Innovative instrumentation developments offer the promise of radically improving these capabilities, thereby stimulating new innovations in materials science. Grant applications must address improvement in electron beam or scanning probe instrumentation capabilities beyond the present state-of-the-art. **Grant applications are sought only in the following subtopics:**

a. Electron Microscopy and Microcharacterization—The Department of Energy supports electron beam microcharacterization of materials as a core research area. Electron microscopy and microcharacterization capabilities are important in the materials and biological sciences and are used in numerous research projects funded by the Department. To support this research, grant applications are sought to develop:

- Stages and holders that provide new capabilities for *in situ* transmission electron microscopy experiments in liquid and/or gaseous environments. Approaches of interest should provide a capability to (1) reach 80 Torr or higher during operation, and (2) apply or measure at least two separate signals, such as current and voltage.

- 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.

- Improved electron detectors suitable for 100-400kV electrons. Grant applications must focus on parallel imaging devices for conventional or scanning transmission electron microscopy. At least one of the following three aspects must be addressed: high quantum efficiency, high spatial resolution, and high temporal resolution. Proposed detectors must be robust and not susceptible to electron beam damage.

- Systems for automated data collection, processing, and quantification. Approaches of interest should include (1) hardware and platform-independent software for data collection and visualization, (2) automated measurement and mapping of crystallography, internal magnetic or electric field, or strain, and (3) multi-spectral analysis. Software and quantification routines for image reconstruction and for interpretation of interference patterns/holography are encouraged.

b. Scanning Probe Microscopy (SPM)—The enabling feature of nanoscience, as 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 scales. Scanning probe microscopy is vital to the advancement of nanoscience and nanotechnology, and is used in numerous materials research projects and facilities funded by the Department. Grant applications are sought to develop:

- New generations of functional SPM probes, sample holders/cells (including electrochemical and photoelectrochemical 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, thermal, and magnetic field sensors – including field effect transistors, single electron transistors, microwave probes, and Hall probes for probing dynamic electrical and magnetic phenomena in the 10 MHz - 100 GHz regime. Probes and probe/holder assemblies should be compatible with existing commercial hardware platforms, or bundled with adaptation kits. 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 and other cantilever 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. Piezoresistive detector demonstrating improved signal to noise are also of interest.

- Systems for next-generation controllers and stand-alone modules for data acquisition and analysis. Areas of interest include: (1) multiple-frequency and fast detection schemes for mapping energy dissipation, as well as mechanical and other functional properties; (2) active control of tip trajectory, grid, and spectral acquisition; and (3) single event detection in molecular systems. Proposed systems should include provisions for rapid data collection (beyond the ~1kHz bandwidth of feedback/image acquisition of a standard SPM), processing, and quantification; and hardware and platform-independent software for data collection and visualization, including multispectral and multidimensional image analysis (i.e., for force volume imaging or other spectroscopic imaging techniques generating 3D or 4D data arrays). For rapid data acquisition systems, software and data processing algorithms for data interpretation are strongly encouraged.

- Environmental SPM systems operating in the 10^{-8} Torr - 1 atm pressure range, supporting existing topographic, electrical, magnetic, mechanical, piezoelectric, and other imaging modes.

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

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6. INSTRUMENTATION FOR MATERIALS RESEARCH USING SYNCHROTRON RADIATION

The Department of Energy supports X-ray scattering and spectroscopy facilities at synchrotron radiation sources where users conduct state-of-the-art materials research. Their experiments are enabled by the convergence of a range of instrumentation technologies. This topic seeks to develop advanced instrumentation that will enhance materials research employing synchrotron radiation. Grant applications should define the instrumentation need and outline the research that will enable innovation beyond the current state of the art. Applicants are strongly encouraged to demonstrate applicability and proper context through collaboration with a successful user of synchrotron radiation sources. To this end, the STTR program would be an appropriate vehicle for proposal submission. Alternatively, applicants are encouraged to demonstrate applicability by providing a letter of support from a successful user. Priority will be given to those grant applications that include such collaborations or letters of support.

A successful user is defined as someone at a research institution who has recently performed synchrotron experiments and published results in peer reviewed archival journals. Such researchers are the early adopters of new instrumentation and are often involved in conceptualizing, fabricating, and testing new devices. A starting point for developing collaborations would be to examine the annual activity reports from synchrotron radiation facilities with links at:
http://www.lightsources.org/cms/?pid=1000444

Grant applications are sought only in the following subtopics.

a. Beam Line Optics— Experiments employing synchrotron radiation are often limited by the beam quality delivered to the research sample. Beam quality requirements depend on specific experiments but usually involve improvements in delivered x-ray flux, brightness, coherence, or focus size. Grant applications are sought to develop advanced instrumentation for focusing, diffracting, or defining the X-ray source that eventually illuminates the research sample. Areas of interest include advancements in mirrors, monochromator crystals, zone plates, etc., in such a manner that improves the beam quality available for materials research. Grant applications should demonstrate an understanding of the state of the art and detail what new types of materials experiments will be enabled by proposed improvements if successfully realized. Grant applications must demonstrate that proposed components and instruments will be able to handle the heating loads from intense x-ray beams, and meet the necessary stability requirements with respect to motion control and vibration isolation.

Questions – contact Lane Wilson at: (lane.wilson@science.doe.gov)

b. Control of Sample Environment—Experiments involving x-rays as a probe have the advantage of being able to penetrate a sample environment and retrieve information from samples that are maintained in realistic environmental conditions. However, the interaction of the x-rays with the environmental container and sample manipulation devices must be controlled to minimize absorption and background scattering. The position of the input and exit beam relative to each other and to the orientation of the sample often also must be carefully controlled. Grant applications are sought to develop technology for sample manipulation, in order to provide for the *in situ* control of environmental parameters. These parameters may include extreme temperatures and pressures, and chemical exposure. Sample manipulation systems of interest should include containers, motion stages, and windows, all compatible with the necessary data collection techniques of an envisioned materials research experiment.

Questions – contact Lane Wilson at: (lane.wilson@science.doe.gov)

c. Detectors—Scattering and spectroscopic data collection involves x-ray detectors that have advanced spatial, energy, and/or time resolution capabilities. The ability to complete a materials research experiment in a reasonable amount of time is often limited by the x-ray detection capability as much as by the quality of the x-ray source. Rapid coverage of the experimental phase space is desired, and multi-element detectors and detector arrays are often employed towards this end. As a result of improvements in x-ray fluxes, detectors often must be able to handle high count rates and large dynamic ranges. Grant applications are sought to advance the state of the art for x-ray detectors. Improvement in the quality and affordability of such detectors is an example of an appropriate area for proposed research. Because detector needs are defined by the needs of a materials experiment, grant applications must detail what new types of materials experiments will be enabled by the proposed improvement, if successfully realized. Although improvements may be incremental, such improvements often generate new opportunities, as rate limiting features move from one item of a beam line system to another.

Questions – contact Lane Wilson at: (lane.wilson@science.doe.gov)

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7. ADVANCED COAL RESEARCH

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon 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. Carbon Dioxide (CO_2) Utilization—Utilization of carbon dioxide (CO_2) has become an important global issue due to the significant and continuous rise in atmospheric CO_2 concentrations, accelerated growth in the worldwide consumption of carbon-based energy, depletion of carbon-based energy resources, and the low efficiency in current energy systems. Barriers to increased CO_2 utilization include: (1) the costs of CO_2 capture, separation, purification, and transportation to the user site; (2) the energy requirement for CO_2 chemical conversion; (3) market size limitations, causing little incentive for investment and a lack of industrial commitment for enhancing CO_2-based chemicals; and (4) the lack of socio-economical driving forces. Therefore, grant applications are sought to develop novel and advanced concepts for capture, reuse, and storage of CO_2 from energy production and utilization systems, based on advanced catalysts for CO_2 or CO conversion. Approaches of interest include the use of CO_2:

- for environmentally-benign physical and chemical processing that adds value to the process.
- to produce industrially useful chemicals and materials that add value to the products.
- for recycling involving renewable sources of energy.

In addition to proposing novel and innovative approaches, grant applications must show clear economic advantages over the existing state of the art.

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

b. Development of NDE Techniques and Monitoring Methods for Continuous Plant Assessment of Critical Components at Temperature and Pressure—Assessing the condition and remaining life of power plant components operating at high temperatures, high pressure, and high stress is necessary to optimize inspection and maintenance schedules, and avoid unplanned outages. Some examples of failure mechanisms include:

- Corrosion and abrasion: for example, fluids within high-temperature high-pressure pipelines, an integral part of fossil energy power facilities, can be corrosive and abrasive. Corrosive media, cavitations, and erosion can lead to pipe leakage and possible failure. Even a small leak in a pipeline could require utilities to shut down a facility to investigate the cause of the leakage. Unscheduled shutdowns cost utilities millions of dollars.

- Creep: power plant components that operate at high temperatures such as boilers headers, steam pipes, valves, and turbine casings are subject to creep failure. Creep damage occurs in different stages, and the first sign is the formation of microscopic cavities at grain boundaries.

- Cracking: in thermal power plants, turbine blades suffer from metal fatigue as a result of vibration. This problem is aggravated by other mechanisms such as creep in the case of high pressure turbines, or corrosion and embrittlement in the case of low pressure turbines.

- Hydrogen damage: failures of waterwall tubes are generic for some condensers; an evaluation of microfissuring would aid in identifying the presence of hydrogen damage.

As power plants reach their designed life, utility owners are forced to make decisions on the status of the equipment. It is essential to identify critical areas where failures may occur and to monitor those areas using suitable nondestructive evaluation (NDE) techniques. Therefore, innovative, low-cost NDE techniques are needed for the continuous on-line or secure wireless monitoring of critical components. NDE techniques of interest must be able to monitor and detect one or more of the following modes of failure: (1) creep and rupture failures, (2) high temperature tensile failures, (3) low cycle fatigue at elevated temperatures, (4) hot corrosion, (5) erosion corrosion, (6) hydrogen embrittlement, (7) microscopic cavities, and (8) microfissuring.

Approaches of interest must include: (1) continuous on-line or secure wireless NDE techniques; (2) a means for interpreting the NDE data collected, and for predicting fitness for service and remaining lifetime of components; (3) low cost monitors, along with an assessment of their reliability of failure detection and their ability to consistently monitor without interfering with plant operations, and (4) an assessment of risk, safety, and economics. In addition, grant applications must recommend at least one candidate site for the viability of commercial-scale testing of NDE methods by industry.

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

c. Oxygen Reduction Catalyst Development—Many high-temperature chemical and electrochemical processes (e.g., oxygen separation membranes, solid oxide fuel cells, and combustion emission-abatement systems) require catalysts for the efficient conversion ("reduction") of oxygen gas into oxygen ions. These catalysts typically are supported by a material that has transport properties tailored to the application, although its role is often of secondary nature. Oftentimes, an additional "promoter" catalyst is employed to enhance the overall reaction rate by tuning the electronic structure of the primary catalyst. In order to guide the development of efficient oxygen reduction catalysts, research is needed to develop correlations between the electronic structure of the catalysts and the facility of the various reactions steps. Therefore, grant applications are sought for the identification of semi-empirical correlations between the electronic structure of oxygen reduction catalysts and their performance, leading to the development of active and stable oxygen reduction catalysts. Approaches of interest should develop (1) a fundamental understanding of how oxygen gas adsorbs, dissociates, and ultimately incorporates into one of the solid phases (either the catalyst or the support); and (2) a strategy for the development of suitable catalysts. Catalysts should be non-noble and appropriate for air environments in the 650°-850°C range.

Phase I should consist of a literature review aided by theoretical and/or computational studies, and should conclude with a comprehensive discussion regarding the promise of various candidate catalysts. Phase II should focus on the development and optimization of promising catalysts from Phase I, with theoretical, computational, and/or experimental methodologies as needed.

Questions – contact Briggs White (briggs.white@netl.doe.gov)

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Subtopic a: Carbon Dioxide (CO_2) Utilization

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Subtopic b: Development of NDE Techniques and Monitoring Methods for Continuous Plant Assessment of Critical Components at Temperature and Pressure

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Subtopic c: Oxygen Reduction Catalyst Development

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8. ADVANCED BATTERY ELECTRODE DEVELOPMENT

World energy consumption is projected to double within 50 years. Electrical energy storage is increasingly being recognized as an essential element in the grid of the future. Electrical energy storage can shave the peaks from a user or utility load profile, increase asset utilization by improving duty factor and delaying utility upgrades, decrease fossil fuel use for ancillary services, provide high levels of power quality, increase grid stability, and smooth the intermittent output of renewable energy sources. At present, utility usage of energy storage is primarily in the form of pumped hydro in the US: water is pumped to an upper reservoir during off peak hours and on weekends and then allowed to drain through turbines into a lower reservoir during peak hours, a basic peak-shaving application. Distributed energy storage near load centers can reduce congestion on both the distribution and transmission systems. Storage operating near an intermittent, renewable wind energy source can smooth out wind variability, lessen the slope on ramp rates, and, if of sufficient scale, can store off peak wind energy.

Batteries are beginning to be used in upgrade deferral applications. However, due to the high maintenance required and low cycle life for lead acid batteries, utilities are interested in finding alternate means of storing energy. The objective of this topic is to improve the performance and manufacturability of advanced utility-scale batteries, reduce their negative environmental effects, ameliorate safety concerns, and ensure the cost effectiveness of these large scale solutions to electrical energy storage. For the large systems associated with utility applications (several MWh or MW), a critical figure of merit is normalized cost (e.g. $/kWh, $/kW), which includes maintenance and life cycle costs as well as select environmental and safety characteristics, at least indirectly. For many battery chemistries, the active electrode materials can figure prominently into these considerations, not only from a raw materials cost and production standpoint but also from a materials performance perspective. Issues such as normalized equivalent weight and volume, improved electrochemical cycle life, and recycling opportunities, to name just a few, should be considered. With this perspective in mind, research efforts related to scalable chemical and electrochemical improvements to active electrode materials are sought. **Grant applications are sought only in the following subtopics**.

a. Novel Electrode Materials (Non-lithium Based Chemistries)—A variety of lithium-based battery chemistries have gained widespread and general acceptance for a number of reasons, including their low normalized equivalent weight and volume. Besides lithium, there are a number of other species that exhibit comparable normalized equivalent weight/volume (e.g. Al, Mg, etc.), provided that the fundamental chemical and electrochemical characteristics can be demonstrated. These characteristics include, for example, their electrochemical and structural reversibility (for secondary battery applications), stability, free energy of reaction (i.e., redox potential), safety, etc. Grant applications are sought to explore and develop novel non-lithium electrode materials (cathode, anode, or both), both conventional and nano-engineered, that have the potential to meet the long term needs for large-scale battery systems.

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

b. Hydride Storage Material for Electrodes in Aqueous Alkaline Chemistries— Nickel-metal-hydride-based battery chemistry plays a significant role in the hybrid electric vehicle market, clearly demonstrating several key aspects of this battery chemistry for larger-scale application needs. Therefore, grant applications are sought to develop novel and/or improved hydride storage materials for electrodes in alkaline systems for large-scale battery applications. Fundamental materials properties desired for these electrode materials include high capacity, good reversibility, stability, electrochemical stability (resistance to oxidation), facile kinetics during both oxidation and reduction (charge and discharge), suitable free energy of reaction (redox potential), etc. As in subtopic a above, both conventional and nano-engineered materials are of interest. Approaches of interest should demonstrate improved performance compared to current state-of-the-art electrode materials (AB_2 and AB_5).

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

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9. MATERIALS FOR NUCLEAR ENERGY SYSTEMS

Nuclear power provides over 20 percent of the current U.S. electricity supply without harmful greenhouse gases or air pollutants, including those that may cause adverse global climate changes. 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. Furthermore, *in situ* materials monitoring sensors that can operate in the high neutron fluence irradiation damage environment for sodium fast reactors, and also can perform well at extreme temperatures (> 900 C) for high-temperature gas-cooled reactors for many years, will be needed to provide non-destructive evaluation methods for continuous or periodic surveillance during normal plant operations and accident conditions.

In addition, to maintain the security of the nation's 104 existing nuclear power plants, research on materials aging and degradation is needed. The safe and reliable operation of nuclear power plants operating in an extended lifetime will require a high degree of confidence in the reliability of nuclear power plants systems, structures, and components. The Light Water Reactor Sustainability Program (reference 7) seeks to develop the fundamental scientific knowledge basis to understand and predict changes in the systems, structures, and components and their materials as they age in a nuclear power plant environment.

Applications that require the handling of radioactive specimens may propose to use the Idaho National Laboratory Advanced Test Reactor National Scientific User Facility and its hot cells, or the Oak Ridge National Laboratory High Flux Isotope Reactor and its radiological examination facilities. Hot cell facilities at Argonne National Laboratory, Pacific Northwest National Laboratory, and Los Alamos National Laboratory also may be considered. **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, grant applications are sought to develop approaches for monitoring these important materials properties in ferritic-martensitic and ODS steels when they are used as in-reactor materials and core barrel/vessel components. Of particular interest are methods that can (1) measure *in situ* irradiation performance; and (2) provide data, in conjunction with non-destructive evaluation techniques, that could potentially yield *in situ* monitoring capability for core/vessel materials performance and detect incremental changes in mechanical properties.

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

b. Advanced Refractory, Ceramic, Ceramic Composite, Graphitic, or Coated Materials—Generation IV Advanced Gas Cooled Reactors (Next Generation Nuclear Plant (NPNG), reference 4.) 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.

Furthermore, use of these advanced irradiation-resistant high temperature materials for gas reactor (NGNP) applications also will require advanced methods for periodic and, eventually, real-time monitoring capability during extreme temperature and flux service conditions. Grant applications are sought to develop advanced methods that can measure the *in situ* irradiation performance of these NGNP refractory, ceramic, graphitic, and coated composite materials. Of particular interest are grant applications for sensors that can (1) monitor the mechanical properties of NGNP in-core/in-vessel materials as they change during their service lifetime and (2) provide accurate and reliable measurements of material mechanical properties during the large temperature changes that occur as the plant operates.

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

c. Advanced Technologies for the Assessment and Mitigation of Materials Degradation for Light Water Reactor Systems and Components—Extending the service-life of the current light water reactor fleet will require a high degree of confidence in understanding and predicting materials performance. New technologies and advances are needed for the long term (e.g., beyond current licensing periods of 60 years) characterization and repair of materials systems experiencing a nuclear power plant environment, and to develop improved methodologies for assessing risk and uncertainty. Therefore, grant applications are sought to develop and demonstrate (1) advanced *in situ* techniques for fundamental phenomenological aging characterization of nuclear-related materials, such as swelling in stainless steel, hardening of reactor pressure vessels and the degradation of concrete; (2) advanced welding techniques for component repair; (3) techniques and processes to mitigate or predict irradiation effects, or other aging phenomena experienced in nuclear reactor components; (4) advanced nuclear fuel cladding materials; and (5) databases and methodologies for assessing risk and uncertainty associated with materials degradation of Light Water Reactor components.

Questions – contact Robert Jordan (robert.jordan2@hq.doe.gov)

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10. SOLID STATE LIGHTING

Today, solid-state lighting (SSL) products fall short of key priced and 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 – has established aggressive and ambitious goals for Solid State Lighting (SSL) R&D. In short, the program seeks to develop advanced SSL technologies that, when compared to other lighting technologies, are much more energy efficient, longer lasting, and cost-competitive. To realize this ambitious long-term goal, a Multi-Year Program Plan (MYPP) has been developed that includes specific performance objectives for contributing technologies such as power supplies and LEDs, as well as for system efficiencies that are compliant with present and anticipated Energy-Star™ requirements. Because not all aspects of the MYPP are suitable for small businesses under the funding and time constraints of SBIR/STTR programs, and for other technical and programmatic reasons, this topic is restricted to selected SSL-contributing technologies described below. Much more comprehensive technical and commercialization information is available at http://www.netl.doe.gov/ssl/.

This project has two distinct themes: subtopics a and b areconcerned with SSL products; subtopics c and d are concerned with SSL core technologies.

By overcoming crucial key technical and design challenges, the DOE believes that some SSL products can be rapidly advanced to the market. This topic seeks general illumination products that push the envelope of SSL performance and cost competitiveness. Among the myriad of performance requirements enumerated in the MYPP, these new SSL products target a system efficiency that is 50 percent or higher with lighting that more completely reproduces the sunlight spectrum. Grant applications submitted to subtopics a and bmust include (1) all required technical information, including specific, quantitative measures of anticipated performance (e.g., color, efficacy, and cost); (2) quantitative comparisons of the proposed product or innovation to existing products, with a clear and demonstrable advantage to the proposed approach; and (3) a clear, viable commercialization plan with identified linkages to a manufacturing route that is compliant with applicable SBIR/STTR guidelines. Special consideration will be give to proposals that emphasize a manufacturing route within the USA.

- The DOE also is seeking to further the development of light emitting diodes (LEDs) and organic LEDs (OLEDs), which are core technologies for solid state lighting. Although grant applications submitted to subtopics c and d need not include a detailed commercialization plan, applicants should indicate how the anticipated intellectual property would be made available for license to a manufacturer or how it would be used to support an existing business relationship or commercialization partner.

Grant applications are sought only in the following subtopics.

a. SSL Products for General Illumination Applications—Grant applications are sought to develop SSL sources, luminaires, and commercial products for general illumination, based on knowledge gained from previously-completed basic and applied research. Ideally, this knowledge would be derived from prior projects supported by the DOE, but any source of R&D funding would still be considered. Potential projects should systematically develop or improve commercially viable materials, devices, or systems, perhaps using technologies that are already in the stream of US commerce. Approaches of interest include the development of: (1) SSL-based integrated luminaires that incorporate the many inherent advantages of Light Emitting Diodes (LEDs) or Organic LEDs (OLEDs), including form factor flexibility for novel optical design, ability to be easily and efficiently dimmed, and operation at low power; (2) high efficiency SSL devices or arrays that are of very high flux with efficient étendue, which offer advancement over conventional designs with respect to extraction efficiency, internal quantum efficiency, current injection efficiency, improved thermal performance, and phosphor system efficiency; and (3) high performance phosphors or encapsulant materials that offer improved quantum yield, broader emission spectrum, reduced thermal quenching, or some other optical-system efficiency advantage that would produce a more efficient, longer lived, or more cost effective product. Proposed product development approaches may include "focused-short-term" applied research, but its relevance to a specific product must be clearly identified.

b. "Off-Grid" SSL Products—The unique, low-voltage, direct-current power requirements of SSL devices are an ideal match to leading photovoltaic (PV) devices and many other renewable sources including wind. The combination of these emerging technologies could lead to the creation of useful products that do not use electric power supplied by the US electric grid. The combination would represent an ideal way to conserve power or to provide lighting service where grid power is either not available or of uncertain reliability. Such illumination devices could serve DOE's energy conservation goals by providing lighting service that is completely removed from the grid. Already, many useful products have been introduced: 45% of commercially available PV/SSL products are used for outdoor lighting applications such as parking lots, walkways, architectural highlights, and illuminated signs. Of this amount, about half are used in the transportation industry for markers, signaling, and other high visibility signs; the other half are used for emergency or industrial applications.

Nonetheless, there is ample room for new, imaginative product ideas that completely remove electric loads from the grid by shifting power requirements to a renewable source, especially in the building sector. When coupled to recent legislation and building code recommendations that encourage more use of renewable energy, there is plenty of financial incentive to include these new products inside the building envelope. Therefore, grant applications are sought to develop novel products that use a combination of SSL, PV and batteries. Product proposals may include architectural façade lighting, remote outdoor lighting, 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 that propose PV/SSL products that fit into the building envelope will be given special consideration. Of particular interest are approaches that (1) use Commercial Off-The Shelf (COTS) technology for the SSL source, photovoltaic collection system, batteries, and controls; and (2) are cost competitive with the designs they replace, as demonstrated by life-cycle cost comparisons.

c. "Core" Technology for Light Emitting Diodes (LEDs)—The DOE has identified a list of contributing scientific issues that are thought to impact the attainment of the DOE's goals for SSL. Grant applications are sought to develop enabling "core" technologies that: (1) increase quantum efficiency, specifically Internal Quantum Efficiency (IQE), of LEDs or phosphor performance, including light extraction, yield, or photonic loss mechanisms; (2) improve thermal management and reliability, and increase device performance of high brightness (HB) LEDs through advancements to contributing materials technologies, such as encapsulating or packaging materials; and (3) improve device life times and cost competitiveness for LEDs by employing advanced designs, device architectures, or novel manufacturing methods, including die growth or alternative substrate materials. Grant applications must specifically address one or more of these areas of interest and completely describe how the proposed technology will produce improvements in performance or cost.

d. "Core" Technology for Organic Light Emitting Diodes (OLEDs)—The OLEDs (both small molecule and polymer) intended for SSL applications possess critical limitations in practical lifetime, particularly when operated at the high current densities required for general illumination applications. These applications entail brightness in the range of 1000 cd/m^2 for prolonged periods of time (>10,000 hours) and operation in hot environments such as commercial buildings ceilings (where temperatures can exceed 125 C). A variety of new materials and architectures of OLEDs have been proposed to overcome these limitations, which could lead to numerous opportunities for improvement. Grant applications are sought to dramatically increase the performance of candidate OLED devices to MYPP levels by producing improvements in blue light performance (spectrum, efficacy and life), charge injection and balancing, electrode materials (reflectivity, transparency and conductivity), device stability and layer compatibility, out coupling enhancements, and thermal management. Grant applications also are sought to develop new and compatible manufacturing technologies to support the anticipated high volume, low cost manufacturing of OLEDs on flexible substrates or thin glass, in order to meet the aggressive price and performance goals of the MYPP.

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11. ADVANCED MATERIALS AND TECHNOLOGIES FOR COOLING AND WASTE HEAT RECOVERY

Refrigeration, air conditioning, and other cooling requirements in the buildings, industry, and transportation sectors account for about 10 quads of U.S. primary energy consumption. Most conventional air conditioners, heat pumps, and refrigerators achieve cooling through a mechanical vapor compression cycle (VCC). The efficiency of the best VCC systems may be approaching asymptotic values; hence, the potential for significant improvement of current technologies may be limited. Further, air conditioning is a major contributor to electric utility peak loads (which incur high generation costs and use equipment with low efficiencies). Similarly, in the transport sector, air conditioning is a large load that constrains the design of hybrid vehicles; overall, A/C accounts for roughly one-fifth of the power required by a mid-sized sedan traveling at 60 mph on a hot day. These factors encourage the search for new approaches to increase the energy efficiency of cooling technologies.

Another problem concerns the adverse environmental impact of the refrigerant gas used in the mechanical VCCs 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. For example, on a per-molecule basis, the refrigerant R-134a used in vehicles 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 R-134a per year. The European Union (EU) bans the use of R-134a in new model cars introduced in 2011 (and in all cars by 2017). There are also large refrigerant losses from residential and commercial air conditioners and refrigerators.

The Department of Energy is seeking the development of advanced technologies for space cooling in buildings and vehicles – as well as for refrigeration in residential, commercial, and industrial applications – that are more energy efficient, that avoid net direct greenhouse gas emissions, that reduce lifecycle costs, and that can impact large markets. Technologies of interest include solid-state materials and devices, advanced working fluids and mechanical vapor compression systems, and advanced contributory technologies such as heat exchangers and heat transfer fluids.

In addition, the Department of Energy is seeking the development of advanced technologies to capture some of the waste thermal energy from processes in the buildings, transportation, and industrial sectors for use in cooling applications or in generating electricity. Many processes within these sectors discharge large quantities of lower-grade thermal energy. Technologies of interest include solid-state materials and devices, and advanced absorption cycles – including those that use solar thermal energy.

Grant applications submitted in response to this topic must: (1) include a review of the state-of-the-art of the technology and application being targeted; (2) provide a detailed evaluation of the proposed technology and place it in the context of the current state-of-the-art; (3) analyze the proposed technology development process, the pathway to commercialization, and the attendant potential public benefits that would accrue; (4)

address the ease of implementation of the new technology, its ability to be installed with commonly-available skill sets, and its potential for high reliability; (5) demonstrate that the proposed technology has the potential to be more energy efficient and have reduced lifecycle costs compared to current technologies; (6) have high reliability; and (7) address a large potential market.

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

Grant applications are sought only in the following subtopics:

a. Solid-State Materials and Devices for Refrigeration and Air-Conditioning Applications—Solid state devices offer the potential to provide higher energy efficiencies than current VCC technologies, to eliminate the use of refrigerants and their greenhouse gas impacts, and to provide highly-durable long-life units. Today, however, solid-state devices such as thermoelectrics have significantly lower efficiencies than conventional VCC technologies. Therefore, grant applications are sought to develop solid state materials and technologies that have the potential to provide improved cost and performance compared to conventional VCC technologies. Grant applications must address (1) solid-state materials and devices such as thermoelectrics, magnetocalorics, electrocalorics, and thermotunneling or (2) other solid state systems.

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

b. Advanced Working Fluids and Mechanical Vapor Compression Systems—Current VCC technologies have a well-established technology, manufacturing, marketing, and support infrastructure around the world. But current VCC technologies appear to have a relatively limited potential for significant further improvements in energy efficiency. Further, current VCC working fluids are strong greenhouse gases. Therefore, grant applications are sought to develop novel working fluids and mechanical VCC systems that have the potential to provide improved energy efficiency and lifecycle cost compared to conventional VCC technologies, with no net greenhouse gas impact due to the working fluid.

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

c. Advanced Heat Exchanger Technologies—Heat exchangers serve as the interface between the cooling technology and the outside environment. Heat exchanger efficiencies and high capital costs remain key constraints in overall cooling system cost and performance. Grant applications are sought to develop heat exchanger technologies with significantly higher performance and lower cost. Approaches of interest include improved materials of construction, improved heat transfer fluid materials (including nanostructured fluids), and improved heat exchanger design.

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

d. Advanced Waste Heat Recovery for Electricity Generation or Cooling Applications—The buildings, transportation, and industrial sectors discharge large quantities of thermal energy from their processes. For example, over half of the energy in gasoline is discharged from a vehicle as waste heat. Systems such as bottoming cycle turbines have long been used for large scale (into the multi-megawatt range) capture of waste heat to produce electricity. At small scales, thermoelectrics have been used in special cases, but their high cost and low efficiency have limited their widespread application. Grant applications are sought to develop (1) solid state materials and devices, such as thermoelectrics or others that can capture waste heat for the production of electricity; and (2) advanced absorption cycles that can use waste heat or solar thermal energy to provide direct cooling for building applications. Approaches of interest must demonstrate that the proposed technology will provide much higher efficiency and lower costs than systems available today.

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

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Subtopics a & d: Solid-state materials and devices such as thermoelectrics, magnetocalorics, electrocalorics, and thermotunneling or other solid state systems;

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12. ENERGY EFFICIENT MEMBRANES

Separation technologies recover, isolate, and purify products in virtually every industrial process. Pervasive throughout industrial operations, conventional separation processes are energy intensive and costly. Separation processes represent 40 to 70 percent of both capital and operating costs in industry. They also account for 45 percent of all the process energy used by the chemical and petroleum refining industries every year. Industrial efforts to increase cost-competitiveness, boost energy efficiency, increase productivity, and prevent pollution demand more efficient separation processes. In response to these needs, the Department of Energy supports the development of high-risk, innovative separation technologies. In particular, membrane technology offers a viable alternative to conventional energy intensive separations.

Successful membrane applications today include producing oxygen-enriched air for combustion, recovering and recycling hot wastewater, volatile organic carbon recovery, and hydrogen purification. Membranes have also been combined with conventional techniques such as distillation to deliver improved product purity at a reduced cost. Membrane separations promise to yield substantial economic, energy, and environmental benefits leading to enhanced competitiveness by reducing annual energy consumption, increasing capital productivity, and reducing waste streams and pollution abatement costs.

Despite the successes and advancements, many challenges must be overcome before membrane technology becomes more widely adapted. Technical barriers include fouling, instability, low flux, low separation factors, and poor durability. Advancements are needed that will lead to new generations of organic, inorganic, and ceramic membranes. These membranes require greater thermal and chemical stability, greater reliability, improved fouling and corrosion resistance, and higher selectivity. The objective is better performance in existing industrial applications, as well as opportunities for new applications. To advance the use of membrane separations, research is needed to develop new, more effective membrane materials and innovative ways to incorporate membranes in industrial processes. Grant applications must address the potential public benefits that the proposed technology would provide, both from reduced energy consumption and from the reduction in one or more of the following: materials consumption, water consumption, and toxic and pollutants dispersion. Grant applications should also include a plan for introducing the new technology into the manufacturing sector, in order to access capabilities for widespread technology dissemination. **Grant applications are sought only in the following subtopics:**

a. Membrane Materials with Improved Properties—Grant applications are sought to develop lower cost inorganic, organic, composite, and ceramic membrane materials in order to improve one or more of the following properties: (1) increased surface area per unit volume, (2) higher temperature operation (e.g., by using ceramic or metal membrane materials), and (3) suitability for separating hydrophilic compounds in dilute aqueous streams. Particular membrane materials of interest include nano-composites, mixed organic/inorganic composites, and chemically inert materials. Particular processes/systems of interest include membranes for the separation of biobased products, membranes for hydrogen separation and purification, membranes for CO_2 capture, and membranes for industrial applications.

For industrial applications, high temperature separations of hydrocarbons and other mixtures are of particular interest. For example, low molecular weight hydrocarbons are separated from natural gas by condensing them as a liquid, and the liquid is distilled to fractionate it, or the liquid is hydrocracked to olefins. However, chilling the natural gas in order to recover the condensable portion and then reheating it is inefficient, because the energy used to chill it cannot be recovered. Membranes, either as stand alone systems or hybridized with other separation technologies, may provide an energy efficient means of separating mixtures at the high temperatures at which these industrial processes are carried out.

For all membrane processes/systems, grant applications must be targeted toward the development of specific membrane materials for carefully defined commercial applications; efforts focused on generalized membrane material research are not of interest and will be declined. In order to assure the rapid commercialization of the technology, especially for use by U.S. manufacturers, applicants are strongly encouraged to engage in partnerships, so that the costs of the technology development and commercialization can be shared among manufacturers, suppliers, and end users.

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

b. Biofuels and Bioproducts—Grant applications are sought to develop membrane technology to enhance the production of biofuels and large-volume, value-added chemical products using biomass feedstocks. These production processes may use either enzymatic or chemical catalysis, and may be conducted in either aqueous reaction media or organic solvents. Grant applications must demonstrate a clear connection to a crop-based feedstock and a large volume chemical product (one that would be manufactured at greater than 500 million pounds). Of particular interest are (1) novel membrane processes that use reactive separation technology, which combines the reactive transformation with the separation; and (2) novel membrane materials with higher flux or selectivity, and with improved chemical and thermal membrane stability. Again, applicants are strongly encouraged to form partnerships involving manufacturers, suppliers, and end users, in order to promote and ensure the rapid development and commercialization of the technology in the U.S.

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

c. Hydrogen Production—Hydrogen can be produced from coal, natural gas, biomass, and biomass derivatives through the use of gasification, pyrolysis, reforming, and shift technologies. In all of these processes, the initial product is a hydrogen-rich producer gas or syngas, from which the hydrogen must be separated and purified. The most common approach today involves the use of pressure swing adsorption (PSA) technology. The use of membranes holds the promise of reducing costs by combining the separation and purification with the shift reaction in a reactive separation operation. Therefore, grant applications are sought to develop improved hydrogen membrane separation and purification technology for use in the production of hydrogen; the focus of the research should be on low cost, high flux rate, durable membrane systems that can be integrated with the shift reaction. Membranes of interest include ceramic ionic transport membranes, micro-porous membranes, and palladium based membranes. Such membranes could be used for a wide range of production capacities, from large central production facilities (50,000-300,000 kgs/day of hydrogen) to small-distributed production units (50-1000 kgs/day of hydrogen). Grant applications must include a careful analysis of the overall hydrogen separation efficiency, to assure that the proposed membrane separation will maximize the hydrogen recovered by the proposed process. Technology partnerships with manufacturers, suppliers, and especially end users are encouraged, in order to assure rapid commercialization of the technology in the U.S.

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

d. Industrial Membrane Process Systems—Grant applications are sought to enhance the separation capabilities of membranes used in industrial process streams. Proposed research should be aimed at developing and commercializing innovative membrane systems, using new or currently existing membranes, that can be robust when integrated within real-world processes (e.g., inert gas removal, isomer separation, aromatic/non-aromatic separations, sulfur removal, CO_2 capture, and removal of trace metals). Grant applications should seek to address one or more of the following needs: (1) techniques for overcoming scale-up problems related to contaminants in industrial streams (fouling, oil misting, etc.), (2) manufacturing technologies that would reduce the cost of membrane modules, (3) anti-fouling and anti-flux schemes to improve the long-term operability of membrane systems, and (4) methods to regenerate membrane performance and lower membrane maintenance costs. Also of interest is the integration of membranes with other technologies (such as the integration of membranes with distillation systems, or with adsorption or extraction processes), in order to address specific process issues. For all grant applications, the overriding goal is to enhance U.S. industrial process efficiency to the maximum possible extent by increasing the separation process efficiency. Therefore, priority will be given to applications that carefully examine the efficiency of the proposed membrane technology within the targeted application. Grant applications should also include a process evaluation and an economic analysis along with the R&D effort. Lastly, technology partnerships involving U.S. manufacturers, suppliers, and end users are strongly encouraged.

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

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13. CATALYSIS

The United States continues to rely on petroleum and natural gas as its primary sources of fuels. As domestic reserves of these feedstocks decline, the volumes of imported fuels grow, and the environmental impacts resulting from fossil fuel combustion become severe, the nation must reassess its energy future. The U.S. Department of Energy recognizes catalysis as an essential technology for accelerating and directing chemical transformation, thereby enabling the realization of environmentally friendly, economical processes for the conversion of fossil energy feedstocks. Catalysis also is the key to developing new technologies for converting alternative feedstocks, such as biomass, carbon dioxide, and water to commodity fuels and chemical products. **Grant applications are solicited only in the following subtopics.**

a. Selective Catalytic Conversion of Fossil Feedstocks—Grant applications are sought to develop new homogeneous and heterogeneous catalysts and catalytic approaches for the efficient industrial conversion of raw paraffins (and napthenes) to commodity fuel and oxygenated products. Approaches of interest are limited to (1) the selective catalytic conversion of hydrocarbons available from petroleum and coal (or the Fischer-Troepsch wax or oil available from coal gasified in air or oxygen enriched air) to fuel hydrocarbons, and (2) the selective direct catalytic conversion of methane, ethane, propane, butanes, and hydrocarbons available from the naphtha fraction of petroleum to commodity oxygenated compounds using air as the oxidant. These catalytic conversions are the most important commercial industrial processes involving hydrocarbons, and include the most energy intensive processes of all industrial processes. Grant applications should identify the barriers to efficient conversion that will be overcome by the proposed research. It is expected that these barriers can be addressed only though innovation research at the fundamental level of chemical catalysis. As such, there may a long time horizon before discoveries will lead to commercially viable technology. Therefore, it is likewise expected that significant industrial interest will be required to continue the development of the catalytic approach to commercial application in US-based chemical and petroleum processing. Grant applications that seek to develop of new catalysts only, outside of the context of hydrocarbon conversion to commodity fuel and oxygenated chemical products, are not of interest and will be declined.

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

b. Biomass Deconstruction and Catalytic Conversion to Fuels—The efficient conversion of lignocelluloses – as available from dried grasses, wood, vegetable residual, etc. – to commodity fuel products represents one of the most formidable technical challenges of the decade. At the present time, all industrial processes for the conversion of such "biomass" starting material to any liquid fuel involves the expenditure of considerably more energy (in one form or another) than is available in the final fuel product. In fact, the most efficient currently-available conversion methods consume multiples of the energy available in the final fuel product. Therefore, grant applications are sought for new catalytic approaches to overcome the fundamental barriers to the efficient conversion of lignocellulose to fuel. Catalytic approaches of interest (1) may be homogeneous, heterogeneous, enzymatic, or any combination of these; (2) may involve only one significant step in the overall conversion process, provided that the step is known to involve a fundamental kinetic barrier to conversion; and (3) may not be a commercially viable product or process itself, provided that the innovation, in conjunction with other viable technology, would make a significant contribution to the economically viable commercial conversion of lignocellulose to liquid fuel products. Ultimately, the result of the research should be a product or process that would attract significant industrial interest and involvement to carry the innovation to commercialization. Because numerous catalytic approaches are currently under consideration, applicants must demonstrate knowledge of the current state of the art, in order to propose a new, significant, and potentially commercially viable innovation catalytic approach for lignocellulose conversion to a liquid fuel product.

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

c. Photo- and Electro-Driven Conversion of Carbon Dioxide and Water—The (Gibbs) standard free energy of formation of carbon dioxide and water from the elements in their standard states involve substantial quantities of energy. Consequently, the conversion of carbon dioxide and water to chemical products also will be energy intensive. Accordingly, to approach anything resembling a commercially-viable chemical process, a process must involve the most efficient conversion steps possible. These conversions are catalytic in nature, and the directed photo- or electro-catalyses of carbon dioxide and water to an end product with commercial value are known (at least in theory) to be specific and active enough to approach a commercially viable chemical conversion process. This solicitation seeks innovative photo- or electro-catalytic approaches for the conversion that will lead (in conjunction with other viable processing steps) to commercial electro- or photo-chemical conversions of carbon dioxide and water to **ANY** final product with more value than the starting materials. Approaches of interest may involve only one step of the conversion, provided that the step is a known barrier to the overall conversion process. Because it is recognized that the research solicited will be part of a long-term effort, grant applications must demonstrate an understanding that the development of commercially viable products or processes will require private investment to bring the innovation to the market.

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

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14. 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 nanomaterial(s) and application will save energy in one or more of the following areas of interest: oil and gas exploration, industrial manufacturing, commercial and residential building HVAC, power electronics, wind energy systems, geothermal energy systems, biomass power systems, advanced hybrid electric vehicles (HEVs), and high-temperature gas turbines. The wider the application and the greater the potential energy benefits, the better. **Grant applications are sought only in the following subtopics.**

a. Nanomaterials—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. Grant applications must address one or more of the following areas of interest: (1) nanomaterials that provide unique wear resistant and erosion-resistant characteristics for improved automotive efficiency (i.e., complete and efficient combustion of fuel), and (2) nanomaterials with high temperature and pressure resistance characteristics for oil and gas exploration and U.S. manufacturing applications. Grant applications dealing with nanocatalysts and related applications are not of interest and will be declined.

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. Grant applications must address one or more of the following areas of interest: (1) energy usage in manufacturing, (2) commercial and residential buildings, and (3) improved automotive performance and fuel economy..

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

c. Nanotechnology Applications in Renewable Energy Conversion and Storage— Grant applications are sought to apply nanotechnology to improve the performance or increase the efficiency of one or more of the following areas of interest: wind energy systems, geothermal energy systems, and biomass power for utility applications. 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. Development of Nanoparticle-sized, "High Voltage" Positive Electrode Materials for Use in Advanced Lithium-Ion Cells—Batteries for Plug-in Hybrid Electric Vehicles (PHEVs) require increased energy density and specific energy relative to batteries now being used in HEVs. For a lithium-ion cell, one approach to increasing these parameters – while also optimizing the ability of the cell to deliver and accept high discharge and charging currents – is to use "high voltage," nanoparticle-sized active materials in the positive electrode. These materials would 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 approximately 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 nanoparticle-sized, positive electrode materials that would be appropriate for use in a lithium-ion cell in a PHEV at voltages greater than 4.8 V relative to lithium metal. In Phase I, the stability and performance of the new material should be confirmed in laboratory cells. In Phase II, the materials should be evaluated in lithium-ion cells of at least 2.5 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. The Phase II evaluation must focus on the performance requirements of a PHEV as described in the references.

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

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15. 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 test procedures or recommended practices as published by the Department of Energy (DOE), the U.S. Advanced Battery Consortium (USABC), or the FreedomCAR Partnership (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 to Assess the Behavior of a Lithium-Ion Cell Containing an Internal Short Circuit—A small fraction of the lithium-ion cells sold for consumer use, mainly in portable electronic devices, have failed in the field. The cells in question are normally of designs that have successfully passed a wide variety of safety tests, such as those required by governmental shipping regulations and by many certification organizations. These failures typically occur after the cell has been in use for at least several months with no previous, obvious problems. When these failures do occur, they can result in the cells getting very hot; some cells will go into thermal runaway and can burn or ignite the device in which they are installed. Failures of this type are often reported in the media as a "burning laptop" and have resulted in the recall of thousands of batteries. Many members of the technical community believe that these failures are caused by a latent flaw that results in a short circuit between the electrodes after significant use. Some reports have suggested that the latent flaw takes the form of a very small piece of foreign material. Battery manufacturers have found it very difficult to study this mode of failure. Therefore, grant applications are sought to develop a method or methods to simulate this type of internal short circuit in lithium-ion cells and to develop methods to prevent such failures and/or mitigate their effects. The ideal method will be applicable to both spirally wound and flat-plate cells containing any of the common lithium-ion electrochemical systems. Approaches of interest must (1) develop a method to introduce an appropriate latent flaw into a lithium-ion cell; (2) "activate" the flaw to produce a short circuit after representative cycling; and (3) then compare the behavior of a cell that fails because of an internal short with the behavior of a similar, unflawed cell that is subjected to one of the standard abusive tests (such as nail penetration) that had been designed to simulate an internal short caused by a latent flaw. Successful grant applications will be specific in their discussion of the methods to be developed to introduce the short and in their approaches to mitigating the effects of such a short.

In Phase I, the proposed technique for introducing and activating a latent flaw should be demonstrated in cells representative of a commercial product of at least 1 Ah in capacity. In Phase II, this latent flaw technique should be (1) demonstrated in both spirally wound and flat-plate cells with capacities of at least 2.5 Ah, and (2) compared to at least one abuse test for simulating the results of an internal short on unmodified cells. Method(s) of preventing or mitigating an internal short may be primarily developed as part of the Phase II effort, but the approach to be taken in prevention or mitigation should be described as part of the Phase I application. Any standard lithium-ion chemistry may be used for these experiments.

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

b. Development of Asymmetric Electrochemical Capacitors—The most common electrochemical capacitors, also known as "super" or "ultra" capacitors, use forms of carbon as the active material in both electrodes. These capacitors exhibit many performance characteristics that make them attractive for use in some HEVs. For example, capacitors can deliver high power discharge pulses, accept high power charging pulses from regenerative braking, have very good cycle life, and operate well at low temperatures. But they have the disadvantage of not being able to store significant amounts of energy on a weight (wh/kg) or volume (wh/l) basis. One way to improve the energy storage capability of a capacitor is to replace one of the carbon electrodes with an electrode made of another material (for example, the non-carbon materials typically used in battery electrodes). When a non-carbon electrode is paired with one of carbon in an electrochemical capacitor, the resulting device is often called an "asymmetric capacitor." Grant applications are sought to develop asymmetric capacitor systems that will store more than 10wh/kg at the cell level while retaining the advantages of high power capability, good cycle life, and good low temperature performance. Other desirable characteristics include limited self discharge, good charge/discharge efficiency, long calendar life, and low cost. Grant applications must provide a clear discussion, based upon available data and theory, to support an assertion that the materials to be developed will offer acceptable performance and meet the energy storage goal. Approaches of interest must include a demonstration of the materials' performance in laboratory cells by the end of Phase I and in capacitors suitable for use in an HEV by the end of Phase II.

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

c. Development of Lithium-ion Cells that Do Not Require the Positive Electrode to Provide the Lithium that Is Cycled—In almost all lithium-ion cells, the "active" lithium that is cycled is introduced into an uncharged cell as part of the material used in the positive electrode. Typical materials that contain "active" lithium include $LiCoO_2$, $LiFePO_4$, and $LiMn_2O_4$. In a lithium-ion cell with a negative electrode made of carbon, a significant portion of the active lithium is consumed during the first charging cycle and represents "irreversible" capacity loss. If a cell has a lithium-metal negative electrode, then the positive electrode does not have to include a material that contains "active" lithium. The use of a negative electrode made of lithium metal allows a cell designer to consider the use of a broader range of electrode materials and to design electrodes without having to accommodate the irreversible capacity loss on the first cycle. Unfortunately, it has proven very difficult to develop cells with lithium metal electrodes that can be cycled thousands of times, as will be required in HEVs and PHEVs. Grant applications are sought to (1) develop a lithium-ion cell in which the active lithium comes from a source other than the uncharged, positive electrode; and (2) then demonstrate that this cell offers advantages relative to conventional lithium-ion cells, with respect to energy density, specific energy, cost, etc. Grant applications should identify what materials will be used in the positive and negative electrodes, what electrolyte will be used, and how the active lithium will be "introduced" into the cell. Proposed approaches that use a negative electrode consisting of pure lithium metal (i.e., a lithium foil electrode) are not of interest and will be declined.

In Phase I, the process for introducing the lithium should be demonstrated in laboratory cells of at least 200 mAh in capacity; these cells may contain a positive electrode representative of the current state-of-the-art for lithium-ion technology. (I.e, the electrode may contain a material such as $LiCoO_2$, $LiFePO_4$, or $LiMn_2O_4$.) Phase II should investigate use of one or more active materials in the positive electrode that do not contain lithium when the cell is built. The Phase II cells, which should be at least 2.5 Ah in capacity, may be either spirally wound or flat-plate designs. The Phase II effort also should address issues associated with manufacturing the cells in large quantities at a competitive cost (e.g., determine whether current procedures and equipment used to manufacture lithium-ion cells could be modified to accommodate the new materials).

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

d. Additives to Reduce the Flammability of Materials Vented from a Lithium-ion Cell—When a lithium-ion cell fails because of an internal flaw or external abuse, the cell case will often vent or rupture. When a cell vents, materials (gases, aerosols, and particles) are often released that can catch fire and burn. Brief periods of burning are undesirable, and sustained burning is very undesirable. Grant applications are sought to develop and demonstrate materials that can be added to a typical lithium-ion cell to reduce the duration and intensity of burning when the cell vents. For the purpose of this subtopic, a "typical" cell is one that uses a mixed-carbonate electrolyte with $LiPF_6$ as the conductive salt. There are no restrictions on the other components of the cell – including anode and cathode materials and minor components of the electrolyte – except that the materials must (1) be described in the proposal; (2) reflect the current state of the art for vehicular applications; and (3) not have an adverse effect on cell characteristics such as cycle life, calendar life, high power capability, self discharge, cost, etc.

In Phase I, the effectiveness of the added materials shall be demonstrated by comparing the duration and intensity of burning of electrolytes in the form of liquids, mists and vapors, with and without the additives. These demonstrations should include a source of ignition but do not have to be done in real cells. Phase I also shall include appropriate, preliminary experiments to demonstrate that the additives do not adversely affect cell performance. In Phase II, the benefits of the additives must be demonstrated by venting abused cells and comparing the burning with and without the additives. In these Phase II experiments, the cells must be of at least 2 Ah in size; and there must be a source of ignition (spark or similar) near the vent. Furthermore, the effectiveness of the additives should be demonstrated under multiple forms of abuse, including external heating, nail penetration, crush, overcharge, short circuit, etc. Phase II also must include experiments to confirm that the additives have not adversely affected the cell performance required of an HEV or PHEV battery. Details of typical performance requirements and of methods of testing for them are described in the references.

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 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. Very useful presentations may also be found by following the links from Conferences → Papers and Presentations → 2008 Vehicle Technologies Annual Review. http://www.eere.energy.gov/vehiclesandfuels/resources/ .

4. Information about requirements for vehicular batteries, separators for lithium-ion batteries, and abuse testing can be found at the USABC section of the USCAR internet site. Go to http://www.uscar.org/; click on the 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.

<u>**OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY**</u>

16. ENERGY SAVINGS TECHNOLOGIES FOR COMMODITY MANUFACTURING INDUSTRIES

Industries consume more energy than any other sector within the US energy economy – including residential and commercial building energy use and the transportation sector. The manufacture of commodity materials – such as basic metals, chemicals, paper, and glass (along with the forming of these materials into basic shapes, such as casting primary metals, plate glass manufacture, shape forming of steel to I-beams or rolls, etc) – consumes more than 70% of all energy consumed by industrial manufacturing in the US.

This topic seeks research and development for new energy savings technologies to be applied in US commodity manufacturing operations, in order to enhance US industrial competitiveness. Applicants must identify the industry and process in which the proposed technology will be applied; approaches that address more than one industrial process or manufacturing sector are most welcome. The proposed technology must be innovative or at least new to the proposed industrial application, demonstrate that the approach will overcome barriers to energy efficiency faced by commodity manufacturers, and provide a reasonable estimate of how much energy (and the form of the energy) can be saved. Grant applications for development of entirely new industrial processes to replace existing processes, or for the development of new commodity materials, are not of interest and will be declined. However, grant applications for the development of new process equipment will be considered responsive, provided that the equipment is needed to complete the feasiblity investigation under Phase I.

Potential applicants are strongly encouraged to develop partnerships with a US-based (of primary US ownership) industrial company, especially one that can support a follow-on commercialization effort. Although new energy savings technologies leading to potential overseas markets are of interest, the R&D must be directed toward industrial processes as they are applied in the United States.

Grant applications are sought only in the following subtopics.

a. Sensors and Controls—Grant applications are sought to develop sensors and controls for existing commodity material manufacturing processes. Of all enhancement options available, sensors and controls provide the greatest opportunity for process efficiency enhancement. Areas of interest include, but are not limited to, process sensors and their associated controls for (1) *in situ* process measurement, expecially for high-temperature processes and (2) for chemical and petroleum product manufacture that do *not* rely on expensive analytical instrumentation. with greatest potential impact on efficiency enhancement but least developed are sensors for.would be of great value for process efficiency improvement but are not widely available. Proposed approaches must culminate in the development and commercialization of new sensor and control systems to be applied in commodity manufacturing processes used in the US. Once the new sensor concept is demonstrated, the applicant would be expected to work with appropriate Government agencies to ensure that the new technology will meet any regulatory bounds for commercialization. However, proposed investigations involving regulatory aspects of new process sensors and controls are not of interest and will be declined.

Questions - contact Brian Valentine (brian.valentine@ee.doe.gov)

b. Agile Manufacturing— Agile or "just in time" manufacturing has been advocated to help manufacturers optimize energy and overall costs for manufacturing the products that consumers order. However, for many industrial processes, the implementatin of such strategies is difficult to envision, because of inherent limitiations of the processes themselves. In particular, few continuous processes can be operated efficiently (if at all) below the rated capacity of the process (for example, it is usually not possible to operate a continuous process at 50% of the capacity for which the process was designed). Grant applications are sought to develop optimization tools and methodologies for specific commodity manufacturing processes that face these limitations. Of particular interest are processes that face severe limitations of this type because of their initial design for "economy of scale." Approaches that deal primarily with software optimization tools will be considered, but applicants are encouraged to develop partnerships with commercial software vendors to commercialize new technology (unless the small business itself is already a commercial software vendor).

Questions - contact Brian Valentine (brian.valentine@ee.doe.gov)

c. Process Heat Transfer Enhancement—Although the possibility of process efficiency improvements based on heat transfer enhancement have been well documented, few new heat transfer enhancement concepts have been commercialized, due to inherent barriers to the commercialization of the concept. For example, heat transfer enhancements based on ultrasound or electromagnetic fields have been demonstrated at laboratory scales, but scale-up to commercial manufacturing levels has not been shown to be possible (or practicable). Grant applications are sought to develop new approaches to overcoming such barriers to the commercial application of heat transfer efficiency improvements in commodity manufacturing processes. Applicants are encouraged to form partnership with manufacturers and/or suppliers, in order to enhance the prospects for downstram commercialization. Also, it is strongly suggested that the utmost care be excercized in researching applicable patent literature; innumerable heat transfer enhancement concepts have been patented but not commercialized, due to the inherent scale-up limitations for commodity manufacturing operations.

Questions - contact Brian Valentine (brian.valentine@ee.doe.gov)

References:

1. Catalysis For Energy, Report from the US DOE Basic Energy Sciences Workshop, August 6-8, 2007.

2. http://www1.eere.energy.gov/industry/about/index.html

3. Industrial Technologies Program Multi-Year Program Plan:
http://www1.eere.energy.gov/industry/about/goals.html

4. National Goal to Reduce Emissions Intensity:
http://www.epa.gov/climatechange/policy/intensitygoal.html

17. INCREASING EFFICIENCY IN TRADITIONAL LIGHTING TECHNOLOGIES

Representing more than 20% of the energy consumed in US buildings, lighting is still mostly produced by mature technologies that evolved during times when 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.

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, especially in lamp system efficiency or efficacy. Any improvements 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 following lamp types contain Hg: linear fluorescent (LFL) and compact fluorescent (CFL) lamps; high intensity discharge (HID) lamps including metal halide, ceramic metal halide, high pressure sodium (HPS), and mercury vapor; and other types of discharge lamps such as mercury short arc, mercury xenon short arc lamps, capillary, and neon. The 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 Brian Valentine (brian.valentine@ee.doe.gov)

b. Fluorescent Lamps and Phosphors—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, resulting in advanced fluorescent lamps with even better efficacy than today's products. 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.

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.

Questions - contact Brian Valentine (brian.valentine@ee.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, thereby 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 Brian Valentine (brian.valentine@ee.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 Brian Valentine (brian.valentine@ee.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_S heet_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. (Website: http://www.eere.energy.gov/

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)

18. PRODUCTION OF BIOFUELS FROM BIOMASS

The Energy Independence and Security Act of 2007 specifies a target quantity of 36 billion gallons of renewable fuels (Renewable Fuels Standard) to be available in the U.S. for domestic consumption by 2022. Of this amount, 15 billion gallons is expected to be provided by conventional corn-based ethanol and 21 billion gallons from advanced biofuels. Of the 21 billion total, 16 billion gallons is expected to come from advanced cellulosic biofuel, 1 billion from biomass-based diesel, and the rest from other sources., In State of the Union addresses (Jan 2006 and Jan 2007), the President 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. These initiatives are efforts 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)**.**

One important component of the achievement of these goals is to ensure that cost competitive feedstocks for biofuels production are widely and sustainably available in sufficient quantities and at reasonable costs. Feedstock costs are a major element in the production of a gallon of biofuel. A joint study by the Departments of Energy and Agriculture released in April 2005 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, which are available primarily as agriculture and forest-derived feedstocks, are enough to produce biofuels that can displace 30 percent of our current gasoline consumption. Research is needed to ensure the cost-effective supply of major biomass resources to biorefineries for conversion to biofuels and bioproducts. The biomass resources should be sustainably available in large quantities, at low cost, and with appropriate quality.

Another component of successfully achieving the above goals involves the cost competitive conversion of biomass to fuels and other bioproducts by both biochemical and thermochemical conversion pathways. The Office of Biomass Program investigates biochemical conversion pathways for the utilization of the cellulose and hemicellulose fractions of biomass to produce ethanol. However, current costs of cellulosic ethanol production are too high to compete in the market, and new approaches are needed to make cellulosic biomass-based technologies more competitive. The Office of Biomass Program also investigates thermochemical conversion of biomass to liquid transport fuels such as ethanol, mixed alcohols, and advanced hydrocarbon-compatible and infrastructure-ready biofuels. Since thermochemical conversion technologies are generally more robust than biochemical conversion technologies, biomass feedstocks can include forest or agricultural residues, energy crops, or the woody fraction of municipal solid waste. Technologies of interest include, but are not limited to, traditional gasification and pyrolysis.

Grant applications are sought only in the following subtopics:

a. Biomass Moisture Management and Material Stabilization—A complete biomass feedstock supply system incorporates elements of labor, machinery, and infrastructure to move biomass from the field to the biorefinery. Feedstock moisture affects all supply chain elements: collection, storage, preprocessing, handling, and transportation. Disregard for biomass moisture can increase feedstock-supply-logistics costs and result in biomass material instability, which is caused by microbial actions. Simply defined, "dry" biomass has a moisture content that is low enough to be aerobically stable, and "wet" biomass has a moisture content that is high enough to require actions (amendments, barriers, etc.) to ensure stability. Microbes react more to "water activity," the available water in the feedstock, than to the bulk percentage of moisture in the biomass. An optimum supply system will balance the costs of handling and storing wet biomass against the costs of removing the moisture and preprocessing the material to a uniform handling format. Grant applications are sought to develop technology to:

- Control/manage biomass moisture, and thus water activity, to provide aerobically stable biomass feedstocks. Approaches of interest should provide the technical and economic feasibility of controlling moisture, through either drying the biomass or adding amendments to lower water activity. Amendment applications would apply the principles of hurdle technology (3) and could consist of any chemical or biological additive to increase feedstock stability.

- Prevent and/or control microbial activity in dry or wet storage. Approaches of interest should allow the biomass to remain stable in storage and throughout the feedstock supply chain, irrespective of absolute moisture content. Stabilization of the material can be based on either by adding a stabilizing agent or by microbial action to preserve the feedstock. Also of interest are advances to traditional ensiling approaches, which would stabilize biomass materials once they are removed from storage.

- Handle feedstocks in unstable situations. Approaches of interest include the optimization of size, recalcitrance, and format considerations to ensure biomass stability throughout the feedstock supply chain. Of particular interest are approaches for handling high moisture biomass without spoilage and handling dry biomass without moisture gain.

Grant applications should be cognizant of the fact that feedstock-supply-system requirements are highly dependent on feedstock variety. For example, the amount of moisture that can be allowed in the biomass, before it becomes aerobically unstable and substantial damage occurs, is feedstock-specific. In addition, different feedstock varieties have varying degrees of available nutrients that affect biological stability and potential losses**.** More biomass feedstocks would be collected as wet (greater than 15-20 percent moisture) than dry. Moisture in feedstock increases the opportunity for unwanted microbial activity and causes degradation to occur more rapidly. Microbial actions on biomass feedstocks typically come at the expense of structural sugars and thus would cause a decrease in feedstock value.

Questions - contact Sam Tagore (Sam.Tagore@hq.doe.gov)

b. Microalgal Feedstock Production—The development of biofuels from conventional terrestrial oil crops and waste cooking oil/fats realistically cannot come close to meeting the demand for diesel transportation fuels (Tyson *et al*. 2004). In 2007, the United States used over 44 billion gallons of on-road petroleum diesel (http://eia.doe.gov), approximately one-third of its annual gasoline usage. Even if all of the vegetable oil and waste fats produced in the U.S. were used for biodiesel production, only 3%-5% of total diesel usage would be replaced. Therefore, viable alternative feedstock sources of high energy density must be developed.

Microalgae represent a promising new source of feedstocks for the production of biobased fuels. Numerous algal strains have been shown in the laboratory to produce more than 50% of their biomass as a lipid with a high fraction of triglycerides, the anticipated starting material for liquid transportation fuels. Algal productivities can be fifty times that of oilseed crops on a per hectare basis. For example, the current estimated oil yields from algae can be 20 times higher than from soybeans. Therefore, less algal biomass is required to produce biodiesel than any other biomass option. It is estimated that algal-derived oil could replace a significant amount of total on-road diesel while using only a fraction of the farmland used for oilseed crops. However, low cost, scalable harvesting options for microalgae do not currently exist. Since algal cultures tend to be relatively dilute cell suspensions, the energy input that is required to remove water from these cultures (including capital and operating costs), prior to oil extraction, can be quite significant (Benemann and Oswald, 1996).

The present slate of available harvesting techniques is costly in terms of both capital and energy input (Benemann and Oswald, 1996). Previous attempts at developing harvesting methods have included (1) chemical flocculation; (2) centrifugation; (3) bioflocculation, the spontaneous flocculation and settling of the algal cells; (4) autoflocculation, the co-precipitation of algal cells with calcium carbonate and other precipitates that form in hard waters subject to high pH; and (5) and spontaneous floatation, due to either cell buoyancy (e.g., high oil content) or the use of a dissolved air flotation process.

Grant applications are sought to develop effective, economical, and sustainable processes to harvest algae for at large-scale applications. Approaches of interest include the use of (1) small amounts of chemical flocculants (polymers), which could be cost effective, depending on the amount used; (2) high gradient magnetic fields to remove algae absorbed on polystyrene beads; and (3) membrane filtration techniques, which have been suggested as an economical way of harvesting large quantities of algae, although no commercial-scale membrane filtration for harvesting algae is currently in use (Gregor and Gregor, 1978).

Any low cost harvesting technology is unlikely to be generic. Although universal harvesting systems have been attempted, experience has shown that such systems are either very expensive or don't work well. Therefore, grant applications should focus on the development of novel harvesting methods that work with certain specific groups of high-lipid-producing algae. In this context, it will be necessary to maintain an effective interaction between the development of harvesting technologies and the selection of particular algal species for possible mass culture applications. A number of features may affect harvestability, including cell size, which can be manipulated through variations in the growth conditions, and electrical charge at the surface of microalgal cells, which can affect the manipulation of environmental and growth conditions. Regardless of the harvesting technique used, the technology solution should be capable of bringing the algal biomass to the density required for oil extraction and further processing (>20% solids content) at a reasonable cost.

Questions - contact Sam Tagore (Sam.Tagore@hq.doe.gov)

c. Small-Scale Transportable Biomass Pyrolysis Technology—Biomass pyrolysis can be used to produce biofuels that directly replace current gasoline and diesel hydrocarbons. In this process, biomass is first converted to liquid pyrolysis oil that is subsequently converted to hydrocarbon fuels. This pyrolysis pathway offers the potential to utilize dispersed, low cost biomass resources, because the initial pyrolysis step can be decoupled from the upgrading of the pyrolysis oil. In smaller units at distributed sites, biomass pyrolysis could potentially utilize a range of biomass resources, such as forest thinnings, to produce a densified oil product, which could, in turn, be processed to finished fuels at larger-scale centralized facilities. Although several pyrolysis approaches currently exist, the technology for economical small scale units, which can be periodically transported from one remote site to another, does not exist.

Grant applications are sought to develop transportable biomass pyrolysis conversion technologies suitable for small-scale operation at capacities up to 50 tons of biomass per day. Approaches of interest must be capable of producing pyrolysis oil yields of at least 55% by weight from biomass, as measured on a dry ash-free basis. The pyrolysis oil produced must be stable, suitable for delivery to a central refinery site, and have a Total Acid Number (TAN) less than 5. The proposed technology may incorporate a variety of underlying pyrolysis approaches but must be self-contained for use at remote sites, such as forest thinning operations. The unit must include capabilities for such requirements as electricity generation or cooling, as needed for remote sites. Finally, the technology must be transportable via roadway for periodic relocation to other remote locations.

Phase I should focus on the system design and provide a technoeconomic analysis of the proposed approach. The technoeconomic analysis should clearly describe the primary components of the system, document projected capital and operating costs, and provide an estimated cost of production ($/barrel, dry basis) of biomass pyrolysis bio-crude oil. These factors will form the basis for determining if the concept has sufficient merit to progress to Phase II.

Questions - contact Sam Tagore (Sam.Tagore@hq.doe.gov)

d. Biomass Densification—Two major characteristics of a raw biomass, its highly variable moisture and its bulkiness, contribute to the high cost of transport and storage. A multitude of factors – including biomass composition, structure, and process temperature, as well as feed rate, particle size, and pressures – are also important. A number of operations – size reduction, drying, and the formation of high density biomass granules (densification) – have been developed to deal with these characteristics, but the high cost of these operations make them unattractive for biorefinery application. For example, roughly half of the power used for forming pellets is wasted to overcome frictional forces in a conventional pellet mill. Size reduction by shear when using a rotary knife consumes almost 1/5 of the power used in hammer milling.

Grant applications are sought to develop an economical processing system for the production of high quality, low cost, granulated densified biomass. Approaches of interest must (1) be applicable to woody and herbaceous biomass and other cellulose biomass; and (2) develop data on capital and operating costs from physical experiments, energy and material balances, biomass properties, and the quality and material handling ability of the finished product.

Grant applications should demonstrate an awareness of new developments in size reduction and densification research. For example, the hydrothermal pre-treatment of biomass prior to densification could provide more structural integrity to pellets. One of these pre-treatment options involves steam explosion, a process by which material is introduced into a reactor and heated under steam pressure at elevated temperatures for a few minutes. The steam-exploded material will have superior binding properties. This process may be suitable for hard to densify/granulate biomass such as cereal straws. However, steam explosion introduces new capital and operating costs to the already high cost of pelletization.

Questions - contact Sam Tagore (Sam.Tagore@hq.doe.gov)

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Subtopic a:

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19. ADVANCED WATER POWER TECHNOLOGY DEVELOPMENT

Advanced water power technologies include (1) new devices capable of extracting electrical power from waves, water currents, and ocean thermal temperature differences; and (2) improvements in the efficiency and/or environmental performance of existing hydropower facilities. Many of the newer marine and hydrokinetic technologies are immature; yet, an emerging domestic and international industry is moving rapidly to develop and deploy demonstration devices. The DOE's Wind and Hydropower Technology Program (WHTP), within the Office of Energy Efficiency and Renewable Energy (EERE), has begun an initiative to accelerate the technology evolution of advanced water power.

Because of the complexity of these technologies, grant applications are expected to focus on a component or subsystem of a specified wave, water current, ocean thermal, or hydropower system that would enable improvements to the overall system. Alternatively, the grant applications could address a subsystem with broader application to multiple water power technologies (e.g. underwater monitoring devices). In either case, the unique function and innovation of the targeted subsystem must be clearly described and its function in relationship to the greater system(s) must be expressed clearly. Approaches of interest can be targeted at any of the multi-step project stages for advanced water power systems: from design concept, through scale model development, laboratory testing, open water testing, full-scale open water testing, and finally commercial demonstration.

Phase I grant applications should (1) thoroughly describe the proposed subsystem or component and how it functions within the overall concept, (2) demonstrate the applicant's knowledge of how to compute energy capture and extraction potential in terms of available energy, and (3) provide an analysis plan to demonstrate the viability and quantify the benefits of the proposed subsystem and the overall concept on the basis of performance and safety. Priority will be given to proposed approaches that demonstrate the likelihood that working prototype subsystem can be successfully demonstrated and integrated into the overall concept by the end of the project.

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 in the following subtopics.

a. Wave and Current Energy Technologies—Wave and current energy technologies have significant potential for utility-scale energy production. However, while dozens of international companies are currently developing systems, only a few commercial scale projects have been deployed worldwide. Grant applications are sought to develop approaches that can advance wave and current energy technologies. Areas of interest include wave energy converters (such as point absorbers, oscillating water column devices, overtopping devices, and attenuators), and energy conversion technologies for tidal, river, and ocean currents (e.g., both axial flow and cross flow turbines are of interest, as well as other methods that can demonstrate reasonable energy conversion efficiency). Grant applications are expected to focus on the detailed development of a selected subsystem or component embodied in a broader concept or device, and must provide: (1) a technical and integrated operational description of the proposed subsystem; (2) a description of how the proposed subsystem integrates into a full energy conversion system; (3) demonstrated understanding of size and strength necessary for long-term in-water survival of the proposed component/susbsystem and, if appropriate, the integrated system; and (4) an analysis of the power performance and energy extraction capability of the proposed component/susbsystem and/or the integrated system, as appropriate, based on available energy. Subsystems and components that do not address a specific device also may be proposed, provided that it is clearly shown that the proposed component or subsystem generically can benefit multiple devices – in these cases, items 3 and 4 above may not be applicable.

Examples of marine and hydrokinetic energy subsystems that might be considered are given below, however other systems or innovations also may be considered:

- Alternative or improved wave capture devices
- Advanced generator concepts
- Alternative fluid power energy conversion systems.
- Subsystems for aggregating power collection and power distribution
- Innovative power distribution couplings, connections, and interfaces
- Load mitigation systems
- Alternative drive concepts
- Mitigation systems to enhance environmental acceptance
- Ecological or physical ocean monitoring systems
- Advanced installation or service equipment.
- Improved rotors or rotor subcomponents.
- Mitigation systems to enhance environmental acceptance
- Ecological or physical ocean monitoring systems
- Advanced installation or service equipment

Questions - contact Alejandro Moreno (Alejandro.Moreno@hq.doe.gov)

b. 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. However, despite large public and private investments over the years, a commercial technology has not yet emerged. The challenges to commercialization include 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 water and cold deep water, and the need to get the electric power to shore; and the difficulties of ocean engineering. Grant applications are sought to apply new technology approaches, currently under development, to address these challenges. These approaches include advances in heat exchanger design and materials and in power conversion systems; the identification of new end products such as ammonia and, in the longer term, hydrogen, which can reduce the geographic constraints; and the increased costs for end products such as ammonia, which would increase the economic potential. Grant applications must provide: (1) a technical and integrated operational description of a proposed OTEC subsystem; (2) a description of how the proposed subsystem integrates into a full energy conversion system; (3) demonstrated understanding of size and strength necessary for long-term in-water survival of the proposed component/susbsystem and, if appropriate, the integrated system; and (4) an analysis of the power performance and energy extraction capability of the proposed component/susbsystem and/or the integrated system, as appropriate, based on available energy. Subsystems may be proposed that do not address a specific device if it can be clearly shown that the subsystems generically can benefit multiple devices. In these cases, items 3 and 4 above may not be applicable.

The Phase I report should (1) summarize and detail the analysis methodology, (2) provide results with respect to cost, performance, reliability, production, external conditions, and operating load responses for particular design load cases, in order to demonstrate the overall performance of the full system.

Questions - contact Alejandro Moreno (Alejandro.Moreno@hq.doe.gov)

c. Advanced Hydropower Systems—Advanced hydropower systems are technologies that improve the energy efficiency and/or environmental performance of existing hydropower turbines, generators, dams, and diversions, including those that increase the water-use efficiency of hydropower projects (i.e., generate more electricity with less water). Some new turbine designs have been proposed recently (e.g., fish friendly designs supported by DOE's Advanced Hydropower Systems Program), but few have been fully tested. Also, automated control technologies and decision support systems, which may offer substantial increases in operational efficiencies along with environmental benefits, have been proposed. Grant applications are sought to new advances for hydropower systems or subsystems, especially those that have combined energy and environmental benefits. Areas of interest include:

- Advanced electrical components for integration of hydropower with other renewables
- Fish-friendly turbine designs
- Variable-speed or high-voltage generators
- Cost-effective flow measurement and turbine control systems
- Advanced weirs for flow re-regulation and aeration
- High-performance materials and coatings to replace existing components

Grant applications must provide: (1) a technical and integrated operational description of a proposed hydropower system or subsystem; (2) a description of how the proposed subsystem integrates into an overall project concept and improves on existing technology; (3) an analysis for determining critical design load cases for the overall concept; (4) an analysis of the power performance and energy extraction capability based on available energy. Subsystems may be proposed that do not address a specific device under development if it can be clearly shown that the subsystems can benefit multiple devices under development generically. In these cases, items 3 and 4 above may not be applicable.

The Phase I report for proposed advanced hydropower systems should (1) analyze the comparative benefits of the proposed technology relative to what already exists; (2) summarize and detail the analysis methodology; and (3) provide results with respect to cost, performance, reliability, production, external conditions, and operating load responses for particular design load cases, in order to demonstrate the overall performance of the full system.

Questions - contact Alejandro Moreno (Alejandro.Moreno@hq.doe.gov)

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20. WIND ENERGY TECHNOLOGY DEVELOPMENT

For over 25 years the Department of Energy's Wind Energy Program, under the Office of Energy Efficiency and Renewable Energy, has been a central component of the Nation's efforts to advance wind energy technology, for both large utility scale and smaller distributed wind systems. To help meet America's increasing energy needs while protecting our Nation's energy security and environment, the Wind Energy Program is working with wind industry partners to develop clean, domestic, innovative wind energy technologies that can compete with conventional fuel sources. Its efforts have culminated in some of industry's leading products today and have contributed to record-breaking industry growth.

Grant applications are sought only in the following subtopics:

a. Manufacturing and Assembly—New tools and designs are needed to reduce manufacturing cost, improve speed of fabrication, and improve the quality of both large- and small-scale wind turbines. Grant applications are sought for developing 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 for small turbines that 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).

b. Component Reliability—Quality assurance is a key element in wind turbine manufacturing. Hidden defects in delivered components could have a major impact on the quality and reliability of the system. Blades, for example, are difficult to inspect due to their large size and thick sections. Improved inspection methods are needed to evaluate bonding quality, thick section infusion, fiber straightness, as well as the wide-area quality of the manufactured composite material. Grant applications are sought to develop new approaches to assuring the quality of manufactured parts before they are shipped to the field. Plant floor manufacturing quality assurance methods that involve advanced non-destructive inspection techniques would be of particular interest.

In addition, grant applications are sought to develop field inspection methods to assure quality during and after installation. Field methods are important for evaluating field repairs and equipment modifications. Methods that uncover hidden defects during the operational checkout phase are of interest, because they could uncover defects generated by the transportation and installation processes.

For both types of inspection procedures, the use of commercially available technology would be appropriate if it can be demonstrated that an innovative application will resolve a unique wind energy problem. Grant applications must: (1) demonstrate that the proposed technology would address important issues and lead to improved reliability of operational wind plants; and (2) demonstrate the economic viability of the technology.

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

c. Condition Monitoring—As wind energy systems increase their penetration into the national
electrical power base, long-term reliability of wind turbines becomes of ever greater importance. Grant applications are sought for new tools and methods to perform real-time and predictive condition monitoring on major wind turbine subsystems, including blades, gearboxes, towers, and generators. Grant applicants should consider (1) advanced sensor systems and instrumentation; (2) models that can predict real-time performance and component failure; and (3) system capability for determining structural condition, reducing unscheduled outages, and predicting failures and maintenance needs in advance.

Proposed systems must be (1) capable of withstanding extreme environments, including high temperatures, high humidity, extreme cold, corrosive offshore environments, and wind-blown sand and dust; (2) flexible in nature, capable of providing a variety of crosscutting condition monitoring applications; and (3) easily integrated into the total wind control platform (including integration into wind turbine fleets or into remote, stand alone, unattended turbines). Both sensors and data acquisition systems must be capable of lifetimes on the order of 20 years or be of such a cost as to make more regular replacement economically viable. The Phase I effort should lead to a demonstration of the system in Phase II, in either simulated or actual operating environments.

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

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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. Commercial geothermal power projects already are operating successfully on identified hydrothermal resources in a number of states. However, a much larger resource base is believed to exist in the forms of "hidden" hydrothermal systems (i.e. systems that have insufficient surface indications) and geothermal systems that can not be produced by conventional means – i.e., without enhancement of their natural permeability or fluid content. Improved technology for locating and characterizing hidden and enhanced geothermal resources is needed to support their development. **Grant applications are sought only in the following subtopics.**

a. Advanced Exploration Technologies for Hidden Geothermal Resources—The resource assessment conducted by the U.S. Geologic Survey projected that the majority of geothermal resources would be found in hidden systems that have no surface indications of deep permeability, temperature, and/or hydrothermal activity. In order to advance technology to meet the goals of the Department of Energy's Geothermal Technologies Program, the uncertainties associated with the barriers that prevent identification and evaluation of hidden hydrothermal potential must be minimized. This will require the development of improved screening methods for site characterization and evaluation. Therefore, grant applications are sought to develop advanced prospecting tools to locate and develop hidden geothermal resources. Of particular interest are approaches to develop reliable geophysical, hydrogeologic, and geochemical surface or shallow bore-hole techniques for imaging subsurface permeability and temperature.

Questions - contact Raymond Fortuna (Raymond.fortuna@ee.doe.gov)

b. High-Temperature Sensors and Components for Geothermal Applications—Grant applications are sought to develop high-temperature sensors and components to enable the subsurface monitoring of geothermal reservoirs during reservoir stimulation and operation. Sensors and components of interest include tilt sensors with resolutions on the order or 0.1 microradian, seismic sensors with frequency responses from sub-Hz to mulit-kHz ranges, fiber optic drivers for high bandwith uphole data transmission, and Gate Turn-Off (GTO) Thyristors for high-voltage motor-control applications. These examples do not represent the full list of required devices but are representative of the range of range of high-temperature technology advances needed to support the development of enhanced geothermal systems. In order to be compatible with packaging for downhole deployment, the sensors and components must be capable of operation within the temperature range from -20°C to +250°C and have expected operating lives of 5000 hours.

Questions - contact Raymond Fortuna (Raymond.fortuna@ee.doe.gov)

c. Flow Path Characterization and Sensing Techniques for Enhanced Geothermal and Hydrothermal Systems—A key aspect of enhanced geothermal systems is the requirement to stimulate the host rock to create a geothermal reservoir. This stimulation, generally accepted to occur via hydraulic fracturing, either creates new fractures in the rock mass or activates pre-existing fractures. Various techniques are used to estimate the extent of fracturing (e.g., microseismic monitoring) and, in-turn, these estimates are used to identify and characterize the available flow paths for fluids injected into the reservoir. Grant applications are sought to develop more direct methods to characterize post-stimulation flow paths. Approaches of interest must be capable of identifying and characterizing the flow paths of working fluids used to remove heat from the reservoir, at depths of between 1 and 10 km and at temperatures up to 300°C. Approaches may make use of estimates of the extent of fracturing; however, the focus of proposed methods must be on the ability to sense and characterize the existence, extent, and movement of fluid paths within the reservoir.

Questions - contact Raymond Fortuna (Raymond.fortuna@ee.doe.gov)

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22. HYDROGEN, FUEL CELLS, AND INFRASTRUCTURE TECHNOLOGIES

Hydrogen is a key part of the portfolio of the DOE's Office of Energy Efficiency and Renewable Energy (EERE), which is working to develop a suite of energy efficient and renewable energy technologies to improve the way we power our homes, cars, and businesses. EERE's Hydrogen, Fuel Cells and Infrastructure Technologies (HFCIT) Program supports research and development efforts needed for the commercialization of hydrogen and fuel cell technologies. The mission of the Hydrogen Program is to research, develop, and validate hydrogen production, storage, and fuel cell technologies and to overcome the non-technical barriers to the commercialization of these technologies. The ultimate goals are to reduce oil use and carbon emissions in the transportation sector and to enable clean reliable energy for stationary and portable power generation. The Program responds to recommendations in the President's National Energy Policy, the Energy Policy Act of 2005, and the Energy Independent and Security Act of 2007.

The widespread use of hydrogen for transportation and stationary power will require cost effective and energy efficient hydrogen production and delivery technologies. For example, the DOE target for hydrogen production cost is $2.00 - $3.00 per gallon of gasoline equivalent (untaxed and delivered to the point of use). The delivery portion of this cost target is $1.00 per gallon of gasoline equivalent, which allows $1.00 - $2.00 for the cost of hydrogen production. From an automotive perspective, the overall cost target would permit hydrogen fuel cell vehicles to compete with gasoline and hybrid gasoline vehicles on a cost per mile basis.

Grant applications are sought only in the following subtopics:

a. Hydrogen Production Process Intensification Technology—Cost savings could be achieved by combining multiple unit operations for the production of purified hydrogen. For example, a rich hydrogen product is produced from the reforming of renewable resources – such as bio-derived liquids, municipal solid waste, and/or the gases from municipal waste landfills – but the product contains contaminants that prevent the direct use of the gas stream in vehicle fuel cells. Therefore, many of these reforming systems utilize pressure swing adsorption and compression to achieve the desired hydrogen purity and pressure. If multiple functions could be provided in a stand alone device, overall process efficiency could be enhanced. Therefore, grant applications are sought to develop new concepts in hydrogen production process intensification for the purification and compression of a reformer-product hydrogen stream. Approaches of interest should:

(1) improve the energy efficiency of separating hydrogen-containing gas streams, with the potential to achieve a production unit energy efficiency greater than 70%;
(2) be functional in low-to-moderate volumes and flow rates (< 100 SCFH);
(3) combine separate processes into a single device, thereby resulting in a low cost, efficient hydrogen production process;
(4) achieve an overall hydrogen cost less than $3.00/kg; and
(5) produce a hydrogen stream at greater than 300 psig, with contaminants at or below concentrations established for PEM fuel cells[1].

Phase I must demonstrate the technology in the laboratory for hydrogen concentrations of 50 and 75 vol% with carbon dioxide as the balance. The temperature of the dilute hydrogen stream should be ambient and the pressure should be 1 atmosphere. A cost estimate of the process should be prepared using the DOE H2A spreadsheet tool[2], and then the estimate should be compared to existing technologies and to DOE cost targets[1].

Questions – contact Rick Farmer (richard.farmer@ee.doe.gov)

b. Hydrogen Home Fueling System—U.S. automakers have invested significant resources in the research and development of hydrogen fuel cell vehicles. However, to enable the widespread use of fuel cell vehicles, an additional major investment will be required to achieve an infrastructure for hydrogen production and delivery to fueling stations. Previous DOE R&D has focused on forecourt fueling stations (1,500 kg H_2/day production) and central hydrogen production facilities (>50,000 kg H_2/day) with promising results.[1-2] As an alternative approach, it has been recommend that the DOE should investigate home refueling concepts for hydrogen.[3] Therefore, grant applications are sought to develop the requirements for a hydrogen home fueling appliance, to examine its infrastructure challenges and required systems engineering.

Approaches of interest include hydrogen production via reforming of natural gas or propane, and/or electrolysis based systems. Approaches must incorporate analyses to identify the hydrogen fueling system requirements including, at a minimum: hydrogen production capacity; expected period of operation (hrs/day); input power requirements; minimum system efficiency; physical size; feed input/requirements; projected life; projected unit cost at builds of 100, 1,000, 10,000, and 100,000 units per year; hydrogen cost per kg; applicable codes and standards that units would need to be met or exceeded; safety requirements; and operation and maintenance procedures that home owners would be willing and able to perform. The delivery pressure should be a minimum of 5,000 psi and the quality should meet SAE TIR J2719 specifications being developed with aid from the U.S. DOE Hydrogen Quality Working Group.[4-5] There is no requirement for off-board hydrogen storage since the hydrogen home fueling appliance would fill the fuel cell vehicle directly.

Phase I must include a feasibility study, an analysis identifying the technical, operational, and safety requirements of the appliance, a preliminary design, estimates of energy use and environmental emissions, a detailed analysis of the process economics for the proposed technology, and a technology development plan. DOE's H2A Production spreadsheet tool[6] should be used to estimate the process economics. Phase II would entail the construction of a proof-of-concept device to demonstrate the technology.

Questions - contact Jamie Holladay (Jamie.Holladay@ee.doe.gov)

c. Modeling of Hydrogen-Dispensing Options for Advanced Storage—An inexpensive hydrogen-fueling infrastructure, which is transparent to the customer, is critical to the widespread adoption of hydrogen vehicles. To this end, the DOE has completed an evaluation of the infrastructure and refilling needs for 35 MPa vehicles. However, to match the range of vehicles with conventional internal combustion engines, hydrogen vehicles will require more hydrogen than can be provided by storage at 35 MPa. Phase I grant applications are sought to analyze and model all of the following five dispensing/storage options (the last three are materials-based storage options):

- 70 MPa compressed gas with pre-cooling to -40C and an overpressure up to 86 MPa
- cryo-compressed gas, which starts as liquid, and is dispensed to the vehicle up to 35 MPa
- metal hydrides – hybrid tanks at moderate pressure
- sorbents – low temperature to room temperature storage at moderate pressure
- chemical hydrides – two-way refueling with recharging of material at a centralized location.

The overarching target for this study is to charge the vehicle with five kg of hydrogen in three minutes. The Phase I modeling/analysis effort must determine the incremental dispenser and station costs of the five delivery technologies beyond the existing 35 MPa refueling infrastructure. The assessment should:

- For each of the five delivery technologies, address the following energy and equipment requirements: (1) compression (or cost savings from reduced pressure needs); (2) cooling of hydrogen or material leaving the dispenser and entering the vehicle; (3) heating of the hydrogen or material leaving the dispenser and entering the vehicle; (4) pumping of a heat transfer fluid at the refueling station; and (5) coarse foot print needs above and beyond a 35 MPa station required for spent fuel or auxiliaries.

- Where appropriate, cover simultaneous gas and material transfer between the station and the vehicle (e.g., liquid hydrogen, powders, viscous materials, slurries, and simple liquids).

- Consider optimum station configurations with respect to gas recirculation and two-way refueling requirements for some combination of the 70 MPa, cryo-compressed, and materials-based storage options. (A broad overview of costs and station upgrade requirements is expected, with the output identifying potential synergies between fueling options and strategies for the evolution of existing 35 MPa stations.

- Include levels of cost uncertainty as a function of the maturity of the technology. Because 35 MPa refueling is mature, it should serve as a foundation for exploring the costs of the other options. For example, the costs for the 70 MPa compressed and cyro-compressed (high pressure liquid) would have more uncertainty (broader error bars). Advanced storage options would be expected to have the most uncertainty.

Phase II of the project would include hardware development of promising technologies. Optimum station layouts should be developed to reduce costs and to accommodate combinations of mature delivery options. The final output should be a roadmap for moving from 35 MPa dispensing to some combination of the five delivery options explored in Phase I.

As additional background information, please note the following:

- The production and delivery of hydrogen to retail stations for dispensing at 35 MPa is characterized in the DOE H2A models. The Hydrogen Delivery Scenario Model (HDSAM V2.0[1]) was released this year and explores the full range of costs, from delivering hydrogen produced at 2 MPa to dispensing it at 43 MPa.

- Advanced storage systems at 70 MPa are used at several locations in the US[2] and cryo-compressed systems on vehicles are currently undergoing testing at National Labs. Cryo-compressed refueling requires liquid hydrogen dispensed at high pressure. Two-way refueling has been developed for low pressure liquid storage systems.

- Additional research and development needed to better understand the next generation of dispensing technologies is described in the Hydrogen, Fuel Cells, and Infrastructure Multi-Year Research, Development and Demonstration Plan[3] and the Freedom Car and Fuel Partnership Delivery Tech Team Delivery Roadmap[4].

- The latest research and advances in storage and delivery can be found in the annual merit review[5] and annual technical progress reports[6].

- A general discussion of existing hydrogen storage options can be found on the DOE tank website pages[7].

Questions - contact Monterey Gardiner (Monterey.Gardiner@ee.doe.gov)

d. On-Line Measurement of PEM Electrolyzer Stacks—Water electrolysis systems provide an opportunity for producing hydrogen and storing energy from intermittent renewable electricity sources such as wind or solar. These systems are well suited for early market hydrogen generation applications because a hydrogen infrastructure is not needed. However, the current cost of electrolysis is 5 to 6 times too high (~$700/kW versus DOE Target of $125/kW). In particular, the capital equipment costs of current water electrolysis systems limit the widespread adoption of this technology. For polymer electrolyte membrane (PEM) water electrolysis systems, the stack costs range from one third to half the cost of the total system.

This subtopic addresses manufacturing cost reductions for PEM electrolyzers. The research effort is part of the DOE Hydrogen Program's initiative to develop low cost fabrication processes for fuel cells, hydrogen storage, and water electrolyzers. This initiative is in response to the President's Interagency Working Group on Manufacturing Research and Development, which developed a plan to strengthen the nation's manufacturing sector and leverage current federal efforts focused on manufacturability issues.

Currently, the production of PEM electrolyzers (which use of dense, unsupported precious metal catalysts) requires the measurement of electrolyzer Membrane Electrode Assembly [MEA] thickness. These measurements are performed on a point-to-point basis, which preclude comprehensive quality checks. The measurement method is also time-consuming, causing a considerable bottleneck in MEA fabrication and stack assembly operation. Therefore, grant applications are sought to develop on-line quality-assurance methods for the measurement of electrolyzer MEA thickness. Approaches of interest must (1) ensure high quality and high-speed throughput for commercial, production-scale volumes to reduce overall manufacturing cost; and (2) develop relationships (transfer functions) between the thickness of electrolyzer MEA components and the electrolyzer's performance. (These relationships must be developed in sufficient detail to provide a basis for controlling the manufacture of MEAs using in-line measurement of physical and chemical properties of MEA components.)

Phase I should result in the design and development of analytical methods for measuring electrolyzer MEA components during manufacture, including (1) the identification and development of methods for measuring the physical dimensions of MEA component layers (membrane and catalyst) during manufacture; and (2) the measurement of the thickness of membranes and catalyst layers that possess different localized thicknesses. Using single cell testing, Phase I also should determine electrolyzer MEA performance and durability differences that result from local variations in the thickness of MEA components.

In Phase II, the electrolyzer MEA thickness measurements should be correlated with performance and durability. This would involve (1) the development of a model to correlate the local variation in the dimensions and composition of MEA components with performance and durability; and (2) establishment of transfer functions based on the model. Phase II also should include an evaluation of the efficacy of the database, model, and transfer function for controlling the manufacture of electrolyzer MEA components and MEAs. Finally, Phase II should determine the effect of the new measurement technology on lowering the cost of an electrolyzer (assuming a manufacturing volume of 500 units per year).

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

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Subtopic a:

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

Subtopic b:

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)

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2. "Fueling Specification for 70MPa compressed Hydrogen Vehicles Release Ver.A", http://www.nextenergy.org/cm/attach/1678F477-F09F-435E-8C75-A519E3245401/Fueling%20Specification%20for%2070%20MPa%20Compressed%20Hydrogen%20Vehicles%20Release%20Version%20(A).pdf

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5. U.S. DOE Hydrogen Program, Annual Merit Review Proceedings, Hydrogen Storage and Delivery http://www.hydrogen.energy.gov/annual_review.html
6. U.S. DOE Hydrogen Program Progress Reports http://www.hydrogen.energy.gov/annual_progress.html
7. U.S. DOE Hydrogen Tank Overview http://www1.eere.energy.gov/hydrogenandfuelcells/storage/hydrogen_storage.htm http://www1.eere.energy.gov/hydrogenandfuelcells/storage/hydrogen_storage_testing.html

Subtopic d:

OSTP National Science and Technology Committee on Manufacturing, “Federal Priorities for Manufacturing R & D”

DOE Hydrogen Program Multi-Year Research, Development and Demonstration Plan

Electric Power Research Institute “Hydrogen Market Assessment and Opportunities for Electrolyzer Based Services”

23. SOLAR ENERGY

Solar energy is an ideal source of power to meet escalating energy demands, because it is clean, sustainable, distributive, and abundant. However, capturing this energy efficiently is problematic. 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. A variety of PV cell technologies – including silicon, thin film, and concentrators – offers great promise in terms of improved efficiency and lower costs. **Grant applications are sought only in the following subtopics.**

a. PV Devices with Reduced Silicon Intensity—The growth of the semiconductor and solar industries has put increasing pressure on limited supplies of high-quality silicon, thus driving up the price of the material by up to 200-800%. Development is underway for a number of processes aimed at reducing the usage of silicon material: kerfless wafering, epitaxial growth, direct solidification, and recrystallization are all thin crystalline silicon processes that promise Si intensity well below 3g/W with cells above 15% efficiency. Grant applications are sought for innovative manufacturing methodologies to produce low cost, high efficiency cells with reduced silicon intensity, while maintaining low capital equipment expenses.

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

b. High Efficiency Organic (OPV) or Sensitized Photovoltaic Cells—Lightweight and flexible conjugated polymer based solar cells currently suffer from low efficiency. Nonetheless such cells represent a highly promising area of low cost PV technology, offering greatly increased functionality and the potential to meet future challenges of scalability, flexibility, integration, and cost. A more effective utilization of the incident solar spectrum (beyond the current wavelength limitation) and into the near infra-red could provide significant improvement in OPV performance. Grant applications are sought for the development of organic or sensitized photovoltaic devices that can achieve high *stabilized* performance with efficiencies approaching 10%. Although increased stabilized efficiency is the most urgent requirement for realizing the promise of this technology, it is important that high performance is achieved with processes and product designs that are relevant to future commercial products.

Comment [SHS1]:

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

c. Advanced Concentrating Systems—Recent progress in high efficiency multijunction cells has fostered considerable interest in concentrating PV. Currently, the majority of efforts in this area involve traditional, non-imaging high-concentration (100-1000x) optics and square cells approximately 1cm^2 in area. Although many companies are beginning to mass produce such concentrating systems, their designs suffer from inherent limitations: (1) the requirement for conventional 2-axis tracking, which increases costs and reduces field packing density; and (2) the significant materials requirements (i.e., for framing, support, etc), which adds cost, complicates manufacture, and creates reliability concerns. Grant applications are sought for innovative concentrating solutions that overcome either of these limitations. Areas of interest include (1) single axis-tracking mid-concentration (10-100x) optical systems, (2) PV device development that achieves the price and performance requirements of the mid-concentration regime (approximately $5-$50/W unconcentrated at 25-35% efficiency), and (3) "micro-concentrating" systems based on small PV devices ($<1mm^2$), which allow substantial improvements to the manufacturing, materials, or reliability limitations listed above.

For utility-scale solar thermal power generation, system capital cost reductions and improved dispatchability are necessary to increase the market penetration of Concentrating Solar Power (CSP). In particular, advancements are needed for solar-collection-field cost reduction, low-cost high-performance thermal energy storage (TES), and high-temperature high-heat-capacity heat transfer fluids (HTF). Therefore, grant applications are sought for (1) low cost solar thermal collection systems or components with high optical and thermal performance and durability, (2) innovative techniques for novel TES that will integrate into one or more of the current CSP technologies, and (3) innovative HTF that are compatible with CSP systems at temperatures typical of state-of-the-art and advanced Rankine steam cycle turbine-generators. Grant applications also are sought for combined heat and power innovations that address market, technological, and supply chain barriers to the wide-spread adoption of this technology.

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

d. Device Manufacturing, Packaging, and Assembly—There is room for improvement in the area of module packaging and assembly. As economies of scale have evolved for device deposition processes, non-device components of modules and systems have become an increased fraction of total PV electrical costs. For these more traditional cost drivers, grant applications are sought to develop innovative solutions to reduce the costs of module components, reduce the cost of installation and maintenance, and increase the lifetime of photovoltaic systems. Areas of interest include (1) module technologies – such as low-cost flexible encapsulants, light trapping layers, advanced contacts, and advanced transparent conductors – which offer increased performance/reliability or reduced costs broadly across the PV industry; (2) building-integrated module designs, optimized system configurations, and innovative deployment options, which offer dramatically lower installation and maintenance costs than conventional approaches; and (3) approaches to improve the lifetime of photovoltaic systems (such as thermal management, material compatibility, and other subsystems impacted by the physical environment) and components (such as inverters, sensors, connectors, capacitors, surge protection, integrated circuits, and input/output ports) subjected to electrical noise, mechanical abuse, and the like. Proposed approaches should identify the critical weaknesses and propose promising and innovative hardware solutions that keep parts counts low, improve reliability, and lower costs for complete systems.

In addition, new techniques have been developed – improved flexible encapsulants, light trapping, advanced contacts, advanced transparent conductors – that offer increased performance/reliability or reduced costs broadly across the PV industry. Sensor and control technologies are needed to ensure that new PV systems can be manufactured to quality standards. Grant applications are sought to develop (1) high throughput analytical tools to characterize the optical and electrical properties of cells and modules; and (2) optical, thermal and electrical methodologies to provide improved control and feedback during manufacturing.

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

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24. IMPROVED MOTOR DESIGNS AND POWER ELECTRONICS ADVANCEMENTS FOR HYBRID AND PLUG-IN HYBRID ELECTRIC VEHICLES

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

- Improved motor designs. Increased magnet material costs are of concern to manufacturers, as this increased cost could limit their acceptance and become a barrier to widespread HEV and PHEV adoption. A better understanding of magnet losses could lead to further optimization in motor designs, enabling magnet material cost savings. In a parallel path, the development of novel motor concepts that use no permanent magnet materials could provide a path to faster adoption of electric propulsion technologies.

- Advances in materials and designs for power electronics and packaging. These concepts – including (1) improved high temperature packaging to reduce cost and improve performance in high temperature applications, and (2) approaches to test component lifetime and predict reliability – 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. Eddy Current Loss Calculation—In the design of conventional permanent magnet (PM) motors with distributed windings, eddy current losses in the magnets are often neglected. However, to obtain accurate efficiency calculations, these eddy current losses must be known. This requirement is especially important for PM motors with concentrated windings, a technology that is re-emerging in PM motor design because of its increased fault tolerance, improved slot utilization, and ease of manufacture. In these machines, larger eddy currents are generated and must be considered to avoid magnet heating problems. The larger eddy currents are the result of time varying fluxes on the magnets at frequencies below the fundamental frequency. In PM machines, these effects are worsened by designs with a larger number of PM poles. For surface mounted PMs, a number of approaches to reduce these eddy currents have been attempted: (1) to section the magnets axially and circumferentially, in order to reduce the eddy current flow path; and (2) to use magnets with reduced conductivity. In all cases, it is still necessary to accurately calculate the eddy current losses.

Grant applications are sought to apply Maxwell's equations to the calculation of eddy current losses and then compare those losses with values measured in the laboratory. Approaches of interest must (1) use commercially available software, (2) apply proper boundary conditions to generate the losses in representative hybrid electric vehicle (HEV) rotor and stator shapes, and (3) perform calculations for both surface mounted magnets and internal permanent magnets. Grant applications also should propose to examine analytical approaches: it will be challenging to analytically determine the benefit of sectioning internally mounted PMs, because of the flux flipping that occurs as the rotor moves. The goal of this research is the development of a technique that can be used not only with the software of choice, but also with other software packages to calculate eddy current losses in the magnets of PM motors. The result should be increased accuracy in the determination of motor efficiency.

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

b. 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 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)

c. High Temperature Packaging—A concerted effort is underway by automotive manufacturers to reduce costs in hybrid electric vehicles (HEVs) and future plug-in hybrid electric vehicles (PHEVs) through the elimination of extra cooling loops. The idea is to utilize the existing loop from the engine, through the radiator, to cool the power electronics. In this scenario, the coolant will reach temperatures as high as 105C at the inlet to the power electronics. Assuming a lifetime of approximately 15 years under these conditions, the power components can be expected to perform satisfactorily for 10,000 temperature cycles. However, depending on the individual drive cycles undergone, an additional 3,000,000 power cycles may need to be endured. As a further complication, existing packaging technologies for the electronics in these advanced vehicles suffer from reliability issues, which are exacerbated by long term thermal and power cycling. Due to the elevated operational temperatures anticipated for the power electronics in HEVs and PHEVs, a pressing need exists for reliable, low cost, high temperature packaging.

Grant applications are sought to develop new packaging and material innovations for high current semiconductors that result in improvements in heat transfer, elimination of hot spots, and volume reductions, while allowing for high current density and a minimization of resistances and inductances associated with power module packages. Concepts and designs of interest include (1) high power insulated gate bipolar transistor (IGBT) modules that achieve low thermal resistance, provide for close matches between the coefficients of thermal expansion (CTEs) of the packaging materials, and the elimination of the wire bonds for increased reliability at elevated temperatures; (2) new methods of die attachment such as sintering along with designs which allow for double sided cooling; and (3) lower cost, higher conductivity direct bonded copper (DBC) materials along with new arrangements for supplying electrical contacts to the terminals. Approaches of interest should lower high-volume manufacturing costs, with particular consideration given to the availability and cost of lead-free high-temperature solders and the effects of solder fatigue in the package over extended operation.

d. Development of an Accelerated Life Test for HEV/PHEV Power Modules—The DOE Vehicle Technologies Program is developing advanced power electronics for future electric, hybrid-electric, plug-in hybrid electric, and fuel cell vehicles. The technical targets for the power electronics for these systems are given in Table 5 of the Electrical and Electronics Technical Team (EETT) Roadmap of the FreedomCAR and Fuels Partnership (see EETT Roadmap 2006, http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/eett_roadmap.pdf). One of the technical targets is a "life" of 15 years or 150,000 vehicle miles while operating with coolant temperatures as high as 105C.

Grant applications are sought to develop an accelerated testing profile capable of demonstrating the 15 year or 150,000 mile life of a hybrid electric vehicle power module. The power module shall be considered to include (1) an inverter for control and conversion of power flow between battery pack and electric machine, and (2) a DC-DC converter to convert from the high to low voltage bus. As an option, the system may also include a bi-directional buck-boost converter for regulation of the inverter voltage with respect to the battery pack voltage.

Approaches of interest must (1) develop a testing cycle for accelerated life testing and life assessment that is backed up by the appropriate failure physics and validated by testing and experiment; (2) lay out the test as a procedure; (3) specify how the mapping of test results will be mapped to life prediction; and (4) specify the test equipment and laboratory facilities that will be used for development and validation.

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

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6 "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.

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3 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)

Subtopic d:

1 Electrical and Electronics Technical Team, November 2006, “FreedomCAR and Fuel Partnership: Electrical and Electronics Technical Team Roadmap” http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/eett_roadmap.pdf

OFFICE OF FOSSIL ENERGY

25. CLIMATE CONTROL TECHNOLOGY FOR FOSSEL ENERGY APPLICATION

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. The state-of-the-art technology for post-combustion CO_2 capture from flue gas is aqueous amine absorption. However, amine absorption has a number of drawbacks, including significant capital and operating costs. Therefore, this topic seeks to develop technologies that can substantially lower the cost of CO_2 capture from flue gas produced by existing coal-fired power plants. Research efforts should demonstrate the viability of the proposed technology to perform with actual flue gas compositions generated from existing coal-fired power plants. Approaches of interest should be capable of 90% or greater reduction in CO_2 emissions per net kWh and result in less than a 35% increase in the cost of energy services. Grant applications should demonstrate familiarity with both current commercial technologies and ongoing research. Incremental improvements on amine-based systems are not of interest and will be declined. **Grant applications are sought only in the following subtopics:**

a. Advanced Solvents for CO_2 Capture from Existing Coal-fired Power Plants— Commercial CO_2 capture solvents, typically based on amines, are in commercial use in scrubbing CO_2 from industrial flue gases and process gases. In these systems, the solvent liquid and the gases typically contact one another in a countercurrent packed column or a spray tower. However, these systems have not been applied to the removal of large volumes of CO_2, as would be encountered in a Pulverized Coal-fired utility boiler flue gas. The key technical challenges to these solvent based systems are: (1) large flue gas volume; (2) relatively low CO_2 concentration; (3) flue gas contaminants; and (4) high parasitic power demand for solvent recovery. Grant applications are sought to develop energy efficient solvents and associated technology for CO_2 capture from existing coal-fired power plants. Technologies should be capable of 90% or greater reduction in CO_2 emissions per net kWh and result in less than a 35% increase in the cost of energy services. Grant applications should demonstrate familiarity with both current commercial technologies and ongoing research.

Grant applications should provide information relevant to overcoming the technical challenges identified above. In particular, grant applications must demonstrate a thorough understanding of the technology being proposed by providing (1) information concerning the solvent composition, molecular weight (or average molecular weight if mixed solvents), boiling point, and chemical and thermal stability; (2) the theoretical maximum CO_2 capacity and target working capacity (in lb CO_2/lb solution); (3) the chemical reactions for the CO_2 absorption/regeneration cycle (and, if available, kinetic data, expected operating temperatures, theoretical regeneration energy, and target regeneration energy as a function of working capacity); (4) an estimate of anticipated solvent cost (if manufactured in large quantities); (5) a description of the stripper configuration; (5) an estimate of all auxiliary power required; and (6) a block flow diagram of how the technology would be retrofitted to a typical pulverized coal fired power plant.

Questions - contact Timothy Fout (timothy.fout@netl.doe.gov)

b. Advanced Sorbents for CO_2 Capture from Existing Coal-fired Power Plants— Solid particles can be used as sorbents to capture CO_2 from flue gas through chemical absorption, physical adsorption, or a combination of the two effects. Possible configurations for establishing contact between the solid particles and the flue gas include fixed, moving, and fluidized beds. The key technical challenges to these sorbent-based systems are: (1) large flue gas volume; (2) relatively low CO_2 concentration; (3) flue gas contaminants; and (4) high parasitic power demand for sorbent recovery. Therefore, grant applications are sought to develop energy-efficient solid sorbents and associated technology for flue gas CO_2 capture from existing coal-fired power plants. Proposed sorbents must be capable of having high CO_2 loading capacities while maintaining particle performance in the presence of flue gas contaminants. Technologies should be capable of 90% or greater reduction in CO_2 emissions per net kWh and result in less than a 35% increase in the cost of energy services. Grant applications should demonstrate familiarity with both current commercial technologies and ongoing research.

Grant applications should provide information relevant to overcoming the technical challenges identified above. In particular, grant applications must demonstrate a thorough understanding of the technology being proposed by providing (1) a description of the proposed configuration for contacting the flue gas with the sorbent; (2) information concerning sorbent particle size, surface area, and active component concentration; (3) the chemical reactions for the CO_2 adsorption/regeneration cycle, along with data for the heats of adsorption of the adsorption/desorption reactions; (4) CO_2 working and theoretical maximum capacity (in mol CO_2/kg sorbent) – working capacity is defined as the difference between the "loaded sorbent" at breakthrough and the sorbent after regeneration, measured at steady-state when cycling between CO_2 absorption and CO_2 regeneration; (5) the anticipated effects of flue gas contaminants and water vapor in the adsorption reaction; (6) the expected performance of sorbent in terms of attrition or blinding; (7) an estimate of sorbent cost (in $/kg sorbent) if manufactured in large quantities; (8) an estimate of all auxiliary power required; and (9) a block flow diagram of how the technology would be retrofitted to a typical pulverized coal fired power plant.

Questions - contact Timothy Fout (timothy.fout@netl.doe.gov)

c. Advanced Monitoring Technologies for Geologic CO_2 Sequestration—Monitoring, Verification, and Accounting (MVA) is defined as the capability to monitor a site for leaks or other deterioration of storage integrity over time, verify that the CO_2 is stored in a way that is permanent, and account for the carbon stored during injection at a specific sequestration site. Grant applications are sought for innovative approaches for (1) technologies that can characterize a CO_2 reservoir and overburden to insure integrity and permanence of storage, and to identify potential leakage pathways; (2) technologies to monitor injected CO_2 temporal-spatial distribution and quantify the amount of CO_2 within a target formation and/or within the overburden and overlying aquifers; and (3) technologies to automate the interpretation of the results from these measurements, in order to speed decision making, conduct multivariate analysis, and/or interpret responses that characterize the phase of CO_2 and leakage pathways. Of particular interest are MVA technologies to measure CO_2 in the target formation, determine the integrity of the seals of the formation (cap rock), and identify leakage pathways and migration of CO_2 out of the formation (between the cap rock and existing drinking water sources).

Approaches of interest include, but are not limited to cost-effective advancements in geophysical, geochemical, hydrologic, and petrophysical techniques such as surface-to-borehole seismic, micro-seismic, cross-well electromagnetic, micro-gravity, water chemistry, novel tracers, tiltmeters, Interferometric Synthetic Aperture Radar (InSAR) and other satellite-based observations, and pressure and temperature sensors.
Questions - contact Karen Cohen (karen.cohen@netl.doe.gov)

d. Advanced Technologies for Mitigating CO_2 Leaks from Geologic Sequestration Sites—CO_2 that is injected into the subsurface for permanent storage is initially kept in place primarily by physical trapping from an overlying impermeable rock layer (cap rock). However, CO_2 injected under pressure has the potential to leak out of the storage formation through open fractures or faults in the cap rock. Other sources of leakage include the injection wells themselves or abandoned wells that may be in proximity to the storage formation**.** Grant applications are sought for advanced technologies that can mitigate leakage of CO_2 from its intended storage site. Approaches of interest include, but are not limited to, pressure control and recapture technologies, and the development of benign materials to isolate, block, plug, or divert leak pathways. In addition, grant applications are sought to develop technologies that advance injection well completion design and materials, in order to ensure that the CO_2 is contained within the target formation and that well integrity is maintained. Grant applications should seek to take advantage of the knowledge base that has been developed for mitigating leakage from projects involving natural gas storage, underground disposal of liquid waste products, and groundwater and soil contamination, all of which may be applicable to CO_2 storage.

Questions - contact Karen Cohen (karen.cohen@netl.doe.gov)

e. Alternative Use and Reuse of CO_2—As high-CO_2-emitting utilities and other industries move toward CO_2 capture technologies to manage greenhouse gas emissions, more and more CO_2 will become available as a resource for multiple applications. In addition, geologic sequestration may not be an option for the storage of CO_2. Therefore, grant applications are sought to develop novel technologies for the use or reuse of captured CO_2. Approaches of interest include (1) the development of technologies for CO_2 conversion to hydrocarbons, solid carbonates, and marketable products that do not easily convert back to CO_2, and (2) the utilization of significant quantities of CO_2 in processes within the oil and gas industry or the chemical industry. For the latter application, it must be demonstrated that the process will not produce more CO_2 than is utilized.

Questions - contact Karen Cohen (karen.cohen@netl.doe.gov)

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a: Advanced Solvents for CO_2 Capture from Existing Coal-fired Power Plants

1. *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/technologies/carbon_seq/refshelf/project%20portfolio/2007/2007Roadmap.pdf)
2. U.S. DOE NETL *Innovations to Existing Plants –CO2 Emissions Control* Web page. (URL:http://www.netl.doe.gov/technologies/coalpower/ewr/co2/index.html.)

b: Advanced Sorbents for CO_2 Capture from Existing Coal-fired Power Plants

1. *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/technologies/carbon_seq/refshelf/project%20portfolio/2007/2007Roadmap.pdf)
2. U.S. DOE NETL *Innovations to Existing Plants –CO2 Emissions Control* Web page. (URL:http://www.netl.doe.gov/technologies/coalpower/ewr/co2/index.html.)

c: Advanced Monitoring Technologies for Geologic CO2 Sequestration

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2. Intergovernmental Panel on Climate Change (IPCC) Special Report on Carbon Dioxide Capture and Storage, 2005, Metz, B., Davidson, O., de Coninck, H., Loos, M., and Meyer, L. (editors), Cambridge University Press, 442 pp. (Full-text available at: http://www.ipcc.ch/ipccreports/srccs.htm)

d. Advanced Technologies for Mitigating CO_2 leaks from Geologic Sequestration Sites

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2. IEA Greenhouse Gas R&D Programme (IEA GHG), "Remediation of Leakage from CO_2 Storage Reservoirs," 2007/11, September, 2007, 438 pp. (Available by request to IEA at URL: http://www.ieagreen.org.uk/2007.html)
3. IEA Greenhouse Gas R&D Programme (IEA GHG), "Safe Storage of CO_2: Experience from the Natural Gas Storage Industry," 2006/2, January, 2006, 123 pp. (Available by request to IEA at URL: http://www.ieagreen.org.uk/2006.html)
4. Intergovernmental Panel on Climate Change (IPCC) Special Report on Carbon Dioxide Capture and Storage, 2005, Metz, B., Davidson, O., de Coninck, H., Loos, M., and Meyer, L. (editors), Cambridge University Press, 442 pp. (Full-text available at: http://www.ipcc.ch/ipccreports/srccs.htm)

e. Alternative Use and Reuse of CO_2

1. 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/technologies/carbon_seq/refshelf/project%20portfolio/2007/2007Roadmap.pdf)
2. Intergovernmental Panel on Climate Change (IPCC) Special Report on Carbon Dioxide Capture and Storage: Chapter 7 – Mineral Carbonation and Industrial Uses of Carbon Dioxide, 2005, Metz, B., Davidson, O., de Coninck, H., Loos, M., and Meyer, L. (editors), Cambridge University Press, p. 319-337. (Full text available at: http://www.ipcc.ch/ipccreports/srccs.htm)

26. OIL AND GAS TECHNOLOGIES

Much of the known reserves of oil and natural gas in the U.S. cannot be recovered by conventional means, and advanced technologies will be required for extraction. This topic seeks to develop technology for two processes that would contribute to the more efficient production of oil and natural gas: (1) new production tools for the efficient and economic recovery of methane from methane hydrates, and (2) innovative methods and concepts to cost-effectively remove salinity (primarily sodium and chloride) from the water produced waters at oil and gas wells. **Grant applications are sought only in the following subtopics:**

a. Methane Hydrates—Grant applications are sought to develop innovative, cost-effective tools and technologies for the viable production of methane from high-saturation, subsurface gas-hydrate accumulations within sandstone reservoirs. Grant applications that seek to modify and improve existing approaches also are of interest. Approaches of interest should (1) identify the most effective suites of drilling, completion, and stimulation methods (including injection of CO_2) to optimize production viability for given geologic settings, (2) provide information on the production rates obtainable from gas-hydrate deposits, and (3) focus primarily on the physical development and testing of production technologies and methodologies. Grant applications based solely on modeling and/or numerical simulation are not of interest and will be declined.

Questions - contact Richard Baker (Richard.baker@netl.doe.gov)

b. Produced Water Treatment Technologies—Grant applications are sought to develop innovative methods and concepts for the cost-effective removal of salinity (primarily sodium and chloride) from the water produced at oil and gas wells. Of particular interest are treatment methods that also can remove other components of produced water, including organic contaminants. The treated water must be in compliance with regulatory requirements so that the water can be discharged to streams and shallow aquifers, or used for beneficial purposes. The waste streams generated by the proposed treatment must be in the form of a concentrated brine, or of a waste solid of minimal volume, in order to facilitate economic disposal. If pre- and/or post-treatment is needed, a detailed description of the additional technologies along with their cost must be addressed in the proposal. Finally, a succinct discussion of the potential technical and economic advantages of the proposed technology – as compared to existing systems – must be addressed in the grant application.

Questions - contact Roy Long (Roy.Long@netl.doe.gov)

References:

Subtopic a: Methane Hydrates

1. Applicants may review information about the DOE's National Methane Hydrate R&D Program and current DOE methane hydrate projects at: http://www.netl.doe.gov/methanehydrates.

2. A listing of specific publications related to methane hydrate research conducted under the program can also be found at: www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/reports/MH42962_FinalRptPhase1A.pdf - 2008-06-03 -

Subtopic b: Produced Water

3. Applicants may review information about produced water and produced water technologies at: http://www.netl.doe.gov/technologies/pwmis/.

27. COAL GASIFICATION TECHNOLOGIES

Coal gasification with steam produces synthesis gas (or syngas, primarily a mixture of H_2 and CO/CO_2). The process offers a versatile and clean way to convert coal into electricity, hydrogen, substitute natural gas, and other clean fuels, as well as high-value chemicals to meet specific market needs. At a time of price hikes of electricity, natural gas, and transportation fuel, flexible gasification systems can provide a capability to operate on the low-cost, widely available, domestic feedstock of coal. The U.S. Department of Energy's Office of Fossil Energy, through its National Energy Technology Laboratory, seeks to enhance the performance of gasification systems to make them cost competitive with alternative processes (e.g., pulverized coal power generation, natural gas combined cycle), thus enticing U.S. industry to implement the environmentally superior gasification-based processes. The enhancements sought will improve economics (e.g. via reducing equipment costs, improving carbon conversion, etc.), improve gasification plant efficiency, assure process environmental performance, and increase process reliability.

One product of coal gasification, hydrogen, can provide viable, sustainable options for meeting the world's energy requirements. DOE/FE's Hydrogen and Clean Fuels Program supports research and development in technologies that can deliver affordable hydrogen from coal with near-zero environmental emissions. The program supports the President's Hydrogen Fuel Initiative, DOE's goals in the Hydrogen Posture Plan, and DOE's long-term goal of producing electricity and clean fuels from coal. In the long-term, research will improve technology that will lower the cost of hydrogen production from coal.

Grant applications are sought only in the following subtopics.

a. Non-Cryogenic Separation of Oxygen from Air—Instead of air, oxygen is a highly desired feedstock for use in coal gasifiers. Oxygen-blown coal gasification produces a nitrogen-free, high-heating-value syngas and provides a promising pathway to coal-based energy generation without carbon emissions. In syngas produced during gasification with oxygen, the CO_2 is present in higher concentrations and at higher pressures than in post-combustion streams. This high partial pressure of CO_2 facilitates more efficient carbon separation, capture, and storage. The most prominent technology for producing the large volumes of oxygen needed for a coal gasification plant is cryogenic air separation. However, this technology is both capital and energy intensive, consuming 10-15% of the gross power output of a gasification-based power plant and accounting for as much as 12-15% of its cost.

Alternate technologies that could produce oxygen more efficiently at a lower cost represent a means to make coal gasification more attractive. Therefore, grant applications are sought to develop non-cryogenic processes for the separation of oxygen from air. These processes must produce high purity oxygen: >95vol% for power generation and >99vol% for chemical and fuel production. Areas of research interest include: (1) novel membranes (excluding ion transport membranes) for air separation, preferably at temperature <200 ºC; (2) oxidation-reduction approaches using appropriate oxygen carriers in a chemical looping concept; and (3) advanced oxygen storage materials that are mechanically stable through thermal and pressure cycles, in order to improve the performance of chemical looping techniques. Any other novel concept capable of advancing non-cryogenic separation processes to produce oxygen in volumes sufficient for coal gasification plant operations, at relevant purities, and in an efficient cost-effective manner – including multi-staged separation processes consisting of different technologies – also would be of interest. Grant applications must describe the potential economic advantage of the proposed approach over conventional cryogenic air separation processes.

Questions: Contact Arun Bose (Arun.Bose@netl.doe.gov)

b. Concepts for Methane-Production in Gasifiers—Natural gas, which is predominantly methane, is widely used in many industries, both as a feedstock for chemical synthesis and as a fuel for power generation. The increasing price of natural gas, along with a diminishing domestic supply of natural gas, creates an incentive for developing low-cost replacement for the fuel. Gasification-based production of methane – via the utilization of abundant, low-cost, domestic coal – offers one means to address these concerns. However, commercially-ready coal gasifiers are predominately designed to produce a syngas that is high in carbon monoxide and hydrogen content while minimizing methane content. Nonetheless, DOE-sponsored R&D in the 1970s and 1980s showed that gasification operations could be modified, or alternate gasifiers could be designed, to produce relatively high concentrations of methane (i.e., >15vol%) in the syngas. Such gasifier products would have a unique opportunity for coupling with solid oxide fuel cells: the endothermic steam-methane reforming reaction facilitates temperature control of the fuel cell and increases the thermal efficiency of the overall process.

Grant applications are sought to develop gasification concepts that produce high concentrations of methane in the gasifier. The primary gasification feedstock must be coal, but feedstock mixtures of coal with biomass, petcoke, etc. will be considered (e.g., 51% to 100% coal on a higher heating value basis). Gasifier operating conditions and design characteristics that might reasonably be expected to influence the methane content of the syngas include, but are not limited to: (1) pressure and temperature; (2) feed media and system (dry vs. wet slurry); (3) coal rank; (4) solids residence time; (5) sizing of the reaction chamber; (6) feed rates of oxidant or steam; (7) particle sizing; (8) feed injector mixing patterns; (9) number and design of gasification stages; (10) the presence of catalysts; and (11) internal separation mechanisms, such as sorbents and/or membranes. Process operating conditions or reactor designs that offer potential advantages in efficiency and cost are preferred, and an assessment of these factors should be included as part of the data evaluation component of the research project. For fuel-cell applications, the minimum concentration of methane in the product from the gasifier, on a dry basis, is 15vol%. For pipeline applications, the gasifier should maximize the conversion to methane (subject to the limitations of thermodynamics, etc.).

This subtopic is restricted to gasifier concepts that produce high-content methane in the syngas. Because the syngas produced in these gasifiers may be targeted for conversion to substitute natural gas and pipeline delivery, concepts for separating carbon dioxide from the methane product will be considered as an implementing technology for methane-producing gasifiers. However, grant applications for processes that perform methanation downstream of the gasifier are not of interest and will be declined.

Questions: Contact Elaine Everitt (Elaine.Everitt@netl.doe.gov)

c. Concepts for Feeding Coal and Coal/Biomass Mixtures into a High-Pressure Gasifier—Current methods of feeding coal to commercial coal gasification systems have an adverse impact on profitability. Water slurry feed systems that smoothly carry the coal to the gasifier results in thermal efficiency losses, a problem that is especially exacerbated with low ranked coals that already have a high water content. Dry feed gasifiers require extensive drying of coal to ensure proper operations of the feed system, also resulting in energy penalties. Moreover, dry feed systems for coal gasification typically incorporate lock-hoppers, which are expensive and unreliable. The elevated operating pressure (in excess of 500 psig) makes solids feeding difficult – the solids (particularly high-moisture feedstocks) often bridge/clog the vessels. Additionally, lock-hopper systems utilize inert gas to pressurize the vessels, which adds diluent to the gasifier and operational costs to the gasification process.

Grant applications are sought to develop devices/systems, which do not include lock-hoppers, for reliably feeding all ranks of coal into a pressurized vessel operating in the range from 500 to 1300 psig, with minimal or no drying of the coal. Proposed approaches must accommodate coal particle sizes less than 100μm in diameter. Because the co-feeding of biomass with coal can reduce the carbon footprint of gasification-based applications, proposed approaches should be flexible enough to feed coal-biomass blends (e.g., 51% to 100% coal on a higher heating value basis), particularly blends that use switchgrass or mixed prairie grass for the biomass component.

Questions? Contact John Stipanovich (John.Stipanovich@netl.doe.gov)

d. Hydrogen Production and Process Intensification—NETL aims to demonstrate the technical/economical feasibility of a coal gasification plant to produce power with near-zero emission of all contaminants, including 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 processed for removing impurities and for improving hydrogen yield through the water-gas-shift reaction. 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 comparable to that of the synthesis gas exiting 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°C to 400°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 in raw gasifier syngases. Grant applications should demonstrate familiarity with current commercial technologies for producing hydrogen from coal, as well as with ongoing R&D supported by DOE in the coal-to-hydrogen program. Areas of interest include membranes and/or other concepts, such as regenerable adsorbents for the recovery of hydrogen from coal gasification streams. Proposed approaches should achieve the following targets: (1) small footprint or high flux rate (for membranes), (2) improved durability, (3) resistance to contaminants, (4) low parasitic power requirements, and (5) low cost, including the cost of fabricating the separation device.

Questions? Contact Dan Driscoll (daniel.driscoll@NETL.doe.gov)

References for subtopics a., b., and c.:

1. Gasification Technologies, U.S. Department of Energy (DOE), National Energy Technology Laboratory Web site: (http://www.netl.doe.gov/technologies/coalpower/gasification/index.html)

2. Gasification Technology R&D, U.S. Department of Energy (DOE), Office of Fossil Energy Web site: (http://www.fossil.energy.gov/programs/powersystems/gasification/index.html)

3. Gasification Systems Technology, Closely Aligned Programs, U.S. Department of Energy (DOE), National Energy Technology Laboratory Web site: (http://www.netl.doe.gov/technologies/coalpower/gasification/programs/index.html)

4. Fossil Energy Cost and Performance Baseline Studies, U.S. Department of Energy (DOE), National Energy Technology Laboratory Web site: (http://www.netl.doe.gov/energy-analyses/baseline_studies.html)

Subtopic a: Non-Cryogenic Air Separation

1. Various presentations and papers located on Gasification Technology Council library webpage http://www.gasification.org/library/overview.aspx for the Air Products ITM Oxygen process. (http://www.gasification.org/Docs/Conferences/2006/54ARMS.pdf, http://www.gasification.org/Docs/Conferences/2005/43ARMS.pdf, http://www.gasification.org/Docs/Conferences/2004/40ARMS_Paper.pdf.)

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2. Topical Report prepared under Contract Number DE-AC21-90MC27227 by Energy Research Corporation, "Design of Gasifiers to Optimize Fuel Cell Systems," February 1992. http://www.osti.gov/bridge/servlets/purl/10153053-XcXbFR/

3. John Ruby, Sheldon Kramer, Raymond Hobbs and Bruce Bryan, "Substitute Natural Gas from Coal Co-Production Project – A Status Report," proceedings of the Twenty-Third Annual International Pittsburgh Coal Conference, Pittsburgh, PA, September 2006

Subtopic c: Concepts for Feeding Coal and Coal/Biomass Mixtures into a High-Pressure Gasifier

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28. USE OF ALGAE FOR FUELS PRODUCTION

Clean forms of energy are needed to support sustainable global economic growth while mitigating greenhouse gas emissions and adverse impacts on air quality. With the United States' economy inextricably linked to liquid fuels to sustain its large transportation sector, an immediate and viable alternative to crude oil is needed to moderate the effect of price hikes and provide an interim bridge until some other fuel source can commercially supplant petroleum-based fuels. This topic concerns the use of algae for fuels production. **Grant applications are sought only in the following subtopics.**

a. Concepts for Extracting Oil from Algae—Biological capture of carbon dioxide is being considered as one method to recycle/reutilize the carbon from power plants. In this concept, carbon dioxide emitted from a power plant would be consumed during algae growth, and the algae would subsequently be utilized for transportation fuels production. Algae is emerging as a promising bio-feedstock for fuels production for two main reasons: (1) the yields of oil from algae are orders of magnitude higher than those for traditional oilseeds (e.g., sunflowers, soybeans, corn), and (2) algae does not require arable land or potable water and can grow in places away from farmlands and forests, thus minimizing the damages caused to the eco- and food chain systems. While the steps between algae growth and biofuel production – e.g., algae harvesting, filtration/dewatering, drying (sometimes), contaminant removal, algal oil extraction, conversion to liquid transportation fuel – have been performed in laboratories, the practical demonstration of these steps require further development, especially at the scales needed to produce meaningful quantities of fuel (i.e., involving acres of algae growth). In particular, the algal-oil-extraction step is one of the most challenging, primarily due to its large cost. The three methods that have been most-often considered for extracting oil from algae are expeller/press, hexane solvent oil extraction, and supercritical fluid extraction. However, each of these methods have drawbacks: the mechanical press generally requires drying the algae, which is energy intensive; the use of chemical solvents present safety and health issues; and supercritical extraction requires high pressure equipment that is both expensive and energy intensive.

Therefore, grant applications are sought to research, design, and develop novel methods for efficiently extracting oil from algae. Approaches of interest may be based on one of the traditional oil extraction concepts as long as innovations to improve process efficiency and economics are introduced. For a process to be considered, it must be shown to be able to generate one liter per day of algal oil in Phase I, and be practical for scale-up and continuous operation in Phase II.

Questions: Contact Elaine Everitt (Elaine.everitt@netl.doe.gov)

b. Converting Algae-Derived Biodiesel into Aviation Fuels—In order to replace the nation's dependence on fossil fuels, many different ideas have been proposed. One of these ideas is to take the oil derived from algae and synthesize biodiesel out of it. While this idea may contribute to the issue of fuel for road transportation, it does not address the biggest user of transportation fuels: aviation, a heavily fuel-intensive method of transportation. The US Air Force alone accounts for the consumption of three billion gallons of fuel every year. Grant applications are sought to develop technology for converting algae-derived biodiesel into various aviation fuels. Grant application must demonstrate knowledge of the algae oil process and familiarity with aviation fuels and biodiesels.

Questions: Contact Elaine Everitt (Elaine.everitt@netl.doe.gov)

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Subtopic a: Concepts for Extracting Oil from Algae

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29. SOLID OXIDE FUEL CELL TECHNOLOGY 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 Integrated Gasification Fuel Cell (IGFC) systems. IGFC systems are attractive alternatives to current technologies in large-scale stationary applications. Electrochemical oxidation of fuel in a SOFC maintains separate air and fuel streams and 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 CO_2 capture (by keeping the fuel and oxidant streams separate) and lower CO_2 generation (as a result of higher efficiency). With these advantages, systems containing improved fuel cell technology in combination with heat recovery subsystems and commercial CO_2 capture technology can meet DOE goals: efficiency greater than 50% (coal HHV to electrical power), NO_x emissions less than 15ppm with 0.5 ppm readily achievable, carbon capture greater than 90% with 99% achievable, and a significantly-reduced water footprint. 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. The following subtopics reflect current R&D needs for SOFCs. **Grant applications are sought only in the following subtopics.**

a. High-Temperature Sealing Systems Based on Viscous Glass—High temperature (650°C to 850°C) planar solid oxide fuel cell (SOFC) stacks are comprised of alternating fuel and air chambers, which are sealed from each other and connected to fuel and air delivery manifolds, respectively. These seals are subject to a demanding set of performance criteria due to the extreme operating environment. The seals must have a low electrical conductivity, be chemically and mechanically stable in a high temperature reactive environment (moist reducing and/or oxidizing conditions), and demonstrate chemical compatibility with the cell and interconnect materials of the particular cell/stack design. Grant applications are sought to develop viscous glass-based sealing concepts for SOFCs. Ideally, the viscous glasses would maintain a softening temperature at or slightly below the lower bounds of the SOFC operating temperature (650°C) and retain suitable viscosity to the upper bound (850ºC), over the life of the seal, and be resistant to devitrification within the SOFC environment. Given that such a glass on its own may be unable to withstand the differential pressure across the seal (up to 2 psid) or the stack bearing load, it is envisioned that an engineered composite solution will be required to carry bearing loads and retain the viscous sealing material. The ultimate objective is the development of an economically-viable seal material followed by a composite system design that can provide sealing under all operating conditions for the life of planar SOFC stacks.

For reference purposes, the sealed perimeter for a single fuel cell-interconnect repeat unit seal is approximately 100cm. Approaches of interest should meet the following performance criteria: (1) volatile constituents (e.g., alkalis) in the seal should be minimized to less than 1% weight loss over 40,000 hours; (2) fuel leakage should be less than one percent (1%), averaged over the seal area and not catastrophic for the duration of the seal life; and (3) the seal material must be capable of a service life of more than 40,000 hours and dozens of thermal cycles for stationary systems. Grant applications also should address manufacturability and cost, two critical factors in meeting SECA program goals.

Phase I should focus on the identification of candidate viscous glasses and conduct rigorous analysis and experimentation to characterize volatility, reactivity, wetting, and viscosity in the SOFC environment. Phase II would entail composite seal design and experimental validation, culminating in larger-scale testing, potentially in partnership with other SECA R&D efforts or one or more SECA Industry Teams. Such partnerships could be achieved through an STTR application.

Questions - contact Travis Shultz (travis.shultz@netl.doe.gov)

b. Cost-Effective Interconnect Coating Process Development—High temperature (650°C to 850°C) planar SOFC stacks are comprised of alternating fuel and air chambers, which are sealed from each other with interconnect plates, typically ferritic stainless steel sheets (e.g., Allegheny Technology's SS441, 0.25mm to 1mm thick) that are stamped to form flow channels for the cathode-side air and anode-side fuel. The purpose of the interconnects is to provide physical separation of the air and fuel streams, electrical conductivity from the anode of one cell to the cathode of the adjacent cell, and mechanical structure to the SOFC stack. Coatings are needed to provide a conductive, protective interface between the porous, electronically conductive cathode contact aid (e.g., LSM) and the native thermally-grown oxide scale (e.g., Cr_2O_3) that forms on the interconnect base material. Therefore, grant applications are sought to identify and develop cost-effective processes to apply high-quality coatings to SOFC interconnects in a mass production scenario. Proposed approaches should (1) seek to maintain the integrity of a dense, crack-free coating layer, which is essential to the long-term performance of SOFCs; (2) apply a coating of cobalt manganese oxide spinel (nominal composition = $Co_{1.5}Mn_{1.5}O_4$) to the cathode side of the interconnect; and (3) emphasize thinner coatings, which have proven to be more resistant to spallation over time. For reference purposes, the interconnect plates are approximately 25 cm x 25 cm in-plane with "lands" and "grooves" of approximately 5 mm in depth and width. Based on the aforementioned interconnect dimensions, and an annual production volume of 250MW of fuel cell stacks per year, approximately 1,600,000 interconnect plates would need coated per year.

Phase I should focus on a comprehensive technical and economic assessment of various coating application techniques, including those already under development within the SECA program:

- The technical assessment should address the ranges for anticipated deposition rates and achievable thicknesses, material utilization rates, yield rates, coating densities, pin holes/cm^2, and thickness variation. A qualitative assessment of any potentially-beneficial process flexibilities or process complexity barriers should be provided, along with a discussion of typical and relevant industrial quality control and assessment measures anticipated. A direct comparison between any proposed application and more well-known coating applications for particular processes (e.g. coatings for computer hard disks, industrial ceramic coatings, etc.) would be especially informative.

- The cost estimate for each proposed coating techniques should include a breakout of the various cost drivers, based on a self-consistent set of assumptions, including geometry similar to that described above.

Phase II would focus on the development and experimental validation of the down-selected coating process(es), culminating in larger-scale testing, potentially in partnership with other SECA R&D efforts or one or more SECA Industry Teams. A detailed economic assessment of the down-selected process(es) should be performed in Phase II.

Questions - contact Travis Shultz (travis.shultz@netl.doe.gov)

c. Novel Contaminant-Tolerant Cermet Anodes— Naturally occurring coal has many impurities, some of which end up in the syngas that is used as fuel for SOFCs. Preliminary studies show that several of these contaminants could have a deleterious effect on the high temperature (650°C to 850°C) planar SOFC stacks comprised of metal–ceramic "cermet" anodes, which function effectively as a fuel oxidizer. The key contaminants are compounds resulting from the gasification of phosphorous, arsenic, and sulfur. Grant applications are sought to identify and develop cermet composites for SOFC anodes that are resistant to coal contaminants. The composite anode must be electrically conductive (>100 S/cm), chemically and mechanically stable in coal syngas at high fuel utilizations (~60% single-pass), and mechanically supportive of a thin (10 μm) ceramic electrolyte (YSZ). In addition, the anode should have a coefficient of thermal expansion (CTE) that is similar to that of the electrolyte (CTE = 11.5×10^{-6} cm/cm °C) and the underlying stainless steel interconnect (e.g. UNS S 44100, CTE = 12.4×10^{-6} cm/cm °C). In addition, a tolerance toward coking at high fuel utilizations would be beneficial to SOFC performance.

Phase I should (1) examine the factors that influence the deactivation of cermets by coal contaminants; (2) propose a novel method or anode formulation that mitigates performance loss; (3) experimentally demonstrate that the concept exhibits considerable promise toward achieving stable, long-term operation in the presence of 1 ppm of PH_3, AsH_3, and H_2S; (4) propose a reasonable manufacturing route for preparing such an anode; and (5) complete an economic assessment of the raw materials costs and processing. Phase II should involve the refining and evaluation of the most promising concepts developed in Phase I, culminating in larger-scale testing under relevant SOFC environments, potentially in partnership with other SECA R&D efforts or one or more SECA Industry Teams.

Questions - contact Paul Tortora (Paul.tortora@netl.doe.gov)

d. Trace Element Removal from Syngas for SOFC Applications— Recent testing has shown that solid oxide fuel cells are susceptible to poisoning by trace amounts of phosphorus and arsenic contained in coal-derived fuel gas. It has been shown via this testing that the maximum concentration of these components in the fuel gas to prevent degradation of the fuel cell is 20 ppb. For advanced gasification processes incorporating SOFC, the polishing step should be conducted at temperature above 250 ºC and at one to five atmospheres pressure.

Phase I should focus on the identification and evaluation of novel approaches to achieve concentrations of phosphorous and arsenic to levels as far below 20 ppb as possible in the fuel gas. Proposed technologies should demonstrate commercial economic potential and have commercial applicability for megawatt scale systems.

Questions - contact Paul Tortora (Paul.tortora@netl.doe.gov)

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Subtopic a. High-Temperature Sealing Systems Based on Viscous Glass

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Subtopic b. Cost-Effective Interconnect Coating Process Development

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Subtopic d. Trace Element Removal from Syngas for SOFC Applications

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Presentations will be posted soon at this link:
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3. Gasification Technologies, U.S. Department of Energy (DOE), National Energy Technology Laboratory Web site: (http://www.netl.doe.gov/technologies/coalpower/gasification/index.html)

4. Gasification Technology R&D, U.S. Department of Energy (DOE), Office of Fossil Energy Web site: (http://www.fossil.energy.gov/programs/powersystems/gasification/index.html)

30. ADVANCED TURBINE TECHNOLOGY FOR IGCC POWER PLANTS

Integrated Gasification Combined Cycle (IGCC) power plants are attractive alternatives to current pulverized coal technologies in large-scale stationary applications. IGCC systems are very efficient, with efficiencies ranging from 35 to 45 percent (depending on system configuration and size). They also are environmentally friendly, emitting lower levels of pollutants and particulates. By using closed loop steam cooling in place of compressor discharge air, current H series gas turbines are able to increase their inlet temperatures (a.k.a. firing temperature) from approximately 1260ºC (2300ºF) to around 1427ºC (2600ºF) and make better use of available compressor air. However, in order to meet long-term Turbine Program goals, which will target efficiencies greater than 50%, the inlet temperature may need to be raised even higher (to 1500ºC (2732 ºF) or higher). Therefore, this topic seeks advances in high temperature materials and hot gas path component cooling, two enabling technologies for higher efficiency and lower emissions. Grant applications are sought only in the following subtopics.

a. Advanced Alloy Development for High Temperature Turbines—Grant applications are sought for research and development to explore advanced alloys for turbine system components. Advanced alloy systems of interest must (1) have high strength at elevated temperatures; (2) withstand the high thermal, creep, and fatigue loads resulting from spallation and/or debonding of thermal barrier coatings (TBCs); (3) provide adequate internal cooling for future high-temperature, high-hydrogen-fired turbine applications; and (4) demonstrate viable extended life (i.e., 8,000-30,000 hrs) in oxidizing high-steam-containing environments, where metal surface temperatures range between 1100-1500ºC. Grant applications should (1) address the viability and/or limitations of current state-of-the-art material systems, as well as systems currently under development, and (2) address the manufacturability, cost, matrix composition, and structural and mechanical properties of candidate materials.
Questions - contact Rondle Harp (rondle.harp@netl.doe.gov)

b. Novel Coating Methods for Unique TBC/Bond Coat Architecture that can Operate at Higher Temperatures—Grant applications are sought for research and development to explore new architectures for thermal-barrier-coating/bond-coat (TBC/BC) materials, such as yttria stabilized zirconia (YSZ), having a coefficient of thermal expansion (CTE) close to that of nickel based super-alloys. Proposed TBC/BC architectures must possess a combination of heat resistance, thermal insulation, and oxygen barrier qualities; hot-corrosion and erosion resistance; long fatigue life, resistance to adverse coating/substrate interaction; adhesion capacity; and high-temperature mechanical performance. In order to define a novel TBC/BC architecture to solve this critical materials issue for the development of advanced gas turbines, approaches of interest should (1) involve a combined study of both metallic and ceramic components; (2) optimize thermal insulation without sacrificing strain tolerance or temperature capability, which would allow a higher surface temperature capability without compromising bond coat stability; and (3) ensure a reliable TBC/BC architecture with a 1300°C TBC surface temperature capability for a minimum of 8000 hours.

The new materials must have low thermal conductivity, have low susceptibility to environmental effects, and withstand the temperature cycles that are expected. It is expected that any proposed TBC/BC architecture will improve the stability of the TBC and the BC:

TBCs must retain their low conductivity and strain tolerance at gas path temperatures up to 1500°C over many thousands of hours. However, current TBCs are susceptible to sintering, phase de-stabilization, and creep above ~1200°C, resulting in degraded compliance and insulation efficiency.

Higher temperatures in the bond coat (BC) also may result in accelerated thickening of the thermally grown oxide (TGO) layer or loss of TGO stability, due to an exacerbated depletion of aluminum (Al) in the BC.

YSZ materials are one of the most efficient thermally insulating oxides. Improvements in thermal resistance will require the incorporation of micro-porosity in the coating. New research efforts are needed to achieve further improvements, based on manipulations of the chemistry and structure of the TBC. The suggested thermal conductivity target is ≤ 0.7 W/mK.

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

c. Innovative Cooling Approaches—Novel and more effective cooling solutions are needed for the hottest sections of the turbine, including the combustor, transition section, first-stage nozzle, stators, rotor blades, and disks. Grant applications are sought for research and development to explore innovative surface cooling and internal cooling approaches that allow ceramic and metal turbine parts to survive in working fluids with higher temperatures. For surface cooling, increased film-cooling effectiveness is needed to improve component durability while decreasing (1) sensitivity to potential surface roughness effects and (2) the propensity to collect deposits in and around cooling-hole exits. For internal cooling, techniques are needed to increase cooling effectiveness and improve component durability, while minimizing cooling air requirements. The effect of proposed approaches on cooling effectiveness should be evaluated, at least analytically, for a range of flow-path heat transfer properties (e.g., resulting from higher water vapor levels) associated with coal syngas and high hydrogen fuels derived from syngas. Experiments to evaluate and demonstrate these approaches and their benefits are desirable.

Preferably, proposed approaches should not increase manufacturing costs significantly. Therefore, applicants are encouraged to explore candidate cooling approaches with turbine suppliers, in order to address their manufacturability.

Questions - contact Charles Alsup (Charles.alsup@netl.doe.gov)

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31. SENSORS AND CONTROLS FOR FOSSIL ENERGY POWER GENERATION SYSTEMS

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

a. Solids Flow Characterization Measurements in High Temperature, Non-Mechanical Valve Systems—In advanced fossil fuel power systems, unique transport and fast fluidization flow regimes create better mixing and, therefore, better efficiency and fuel consumption. These conditions could be optimized by improving the measurement of solids flow, as well as particle flow characteristics. The ability to obtain these measurements by utilizing non-mechanical valves (as opposed to the more obtrusive mechanical valves) would be particularly valuable, especially in coal fired power plants where hot, burned, spent ash and sorbent are recycled and combined with feedstock in such transport systems as circulating fluidized beds (CFB). Such non-mechanical valves also would be valuable in chemical looping systems to transfer solids between different reactor vessels. Grant applications are sought for solids flow characterization devices that use non-mechanical valves and can withstand the harsh environments of coal fired plants. The environment includes high temperatures (800-1500°C), high pressure (500-1000 psi), and corrosion due to high flow rates of abrasive materials and slag. Approaches of interest include:

(1) The development of a continuous, non-obtrusive, solids-circulation monitoring device – the device must be suitable for continuous use, minimize any loss of availability of the plant as a result of using the device, and provide on-line calibration methods to ensure that feed rates can be controlled with an accuracy of ±5%.

(2) A method to obtain simultaneous particle velocities and concentrations to enable diagnostic characterization of the flow structure over a wide range of flow regimes. The measurement device must provide spatial resolution at the millimeter length scale and temporal resolution at the millisecond time scale, be non-intrusive, and be capable of obtaining full three-dimensional tomographic images over at least a 1-foot diameter, using techniques such as ultrasound, acoustic, x-ray, or capacitance techniques. On-line quantitative calibration methods are required over the entire range, from 0.01 to 0.5 solids volume

fraction, to ensure that solids concentrations and velocities can be measured with an accuracy of ±1%. Devices can be demonstrated in a cold flow unit.

Questions: Contact Steven Seachman (steven.seachman@netl.doe.gov)

b. Development of Standard Packaging and Integration of Sensors for On-Line use in Harsh Environments—The high-temperature harsh environment of an advanced power system requires several types of measurements (e.g., temperature, pressure, strain, and gas composition) to be made in order to operate and control the system efficiently. Different sensor probes are required to measure each parameter. While much success has been realized in the area of sensor materials and designs for these environments, very little work has been devoted towards the integration of sensor devices into commercial-scale systems through the use of packaging designed for harsh environments. The lack of a standardized package for micro sensors serves a barrier to the commercial use of these devices. For development efforts, packaging is essential to conduct long term pre-commercial testing. Grant applications are sought for standardized packaging of fiber optic or MEMs-based sensors in high temperature (500-1000^{o}C) and harsh (strongly reducing or oxidizing conditions, particulates, etc.) environments. A robust approach to the packaging of these sensors is desired, in order to enable their ease-of-use and application to on-line sensing for commercial full scale power systems.

Grant applications should develop a detailed approach that focuses on a general sensor type (fiber optic or MEMs) and one or more fossil fuel-based power systems (e.g., coal-fired boiler systems, coal gasification systems, land-based gas/syngas turbines, solid oxide fuel cell power systems). For fiber optic sensors, the approach to packaging may depend on the sensor configuration (e.g., single point measurement, multiple measurements within a fiber bundle, and/or multiple sensors distributed along the length of a single fiber).

Questions: Contact Robie Lewis (robie.lewis@netl.doe.gov)

c. New Approach to Process Control Architecture for Operation of Large Scale Central Power Systems— Grant applications are sought for novel approaches to the control system architecture for large scale central power systems. Approaches of interest should depart from traditional hierarchial control systems and consider emerging approaches for managing a large number of system inputs and outputs, including the use of (1) sensor networks with computing, communication, and logic capability; and (2) high performance process models for control.

Grant applications should (1) identify a formal approach to the utilization of dense, pervasive, and highly intelligent sensor networks; (2) demonstrate a predictive capability in a decentralized platform; and (3) describe the potential advantages and disadvantages of the proposed approach. Approaches based on PID (Proportional-Integral-Derivative) control are not of interest and will be declined.

Questions: Contact Susan Maley (susan.maley@netl.doe.gov)

References:

Subtopic a: Solids Flow Characterization Measurements in High Temperature, Non-Mechanical Valve Systems

Park, J., et al., "The control of bed height and solids circulation rate in the standpipe of a cold flow circulating fluidized bed." 2005 (full text available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TH9-4FNDS2X-1&_user=2638189&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000058399&_version=1&_urlVersion=0&_userid=2638189&md5=4f5fdfc63b3298da7fa6981430d8005f)

Lui, S., Electrical capacitance tomography for gas–solids flow measurement for circulating fluidized beds (full text available at http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V38-4G3KBTC-1&_user=2638189&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000058399&_version=1&_urlVersion=0&_userid=2638189&md5=3979fd2220f97404d81486154b7f3be3)

Descriptions of the fossil fuel-based power systems can be found at www.netl.doe.gov and descriptions of a select number of sensor development projects are also listed on NETL's website.

Subtopic b: Development of Standard Packaging and Integration of Sensors for Industrial on-line use in Harsh Environments

Descriptions of the fossil fuel-based power systems can be found at www.netl.doe.gov and descriptions of a select number of sensor development projects are also listed on NETL's website.

Subtopic c: New Approach to Process Control Architecture for Operation of Large Scale Central Power Systems

Please refer to www.netl.doe.gov for a description of the advanced power plants currently under development.

32. HIGH PERFORMANCE MATERIALS FOR FOSSIL ENERGY POWER GENERATION SYSTEMS

This topic seeks to increase power plant efficiencies by developing advanced materials for long-term operation in power plants at elevated temperatures and pressures. High performance materials are required to significantly improve performance and reduce the costs of existing fossil systems, or to enable the development of new systems and capabilities. These materials must be suitable for long-term 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, etc.). Grant applications are sought only in 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. For example, in a coal-fired boiler, oxidizing and corroding environments range from simple gas attack (i.e., oxidizing mixtures of O_2 and SO_2/SO_3) to deposition microclimates of complex nature. The latter involve complex mixtures that include aggressive gaseous compounds (such as H_2S, HCl, COS, CS_2, CO, and methyl mercaptan), usually generated during the substoichiometric combustion of coals when modified combustion systems are implemented for NOx emissions control. These substoichiometric combustion processes generate unburned carbon and pyritic particulate that, based 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 otherwise costly nickel-based materials. For example, the science of thermal spray 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 develop new surface modification techniques, or to optimize the techniques mentioned above, for the protection of high temperature alloys used in ultrasupercritical coal-fired boilers.

Questions - contact Richard Read (Richard.read@netl.doe.gov)

b. Sealing Technology for Gas Separation Devices—In processes for high-efficiency low-emissions fossil energy conversion, advanced sealing materials are needed to hermetically join the inorganic membranes used in high temperature gas separation to the underlying support structure of the separation device. Ceramic membranes, which have operating temperatures between 250 and 1000ºC, are attracting increasing attention because of their technological importance in high temperature gas separation and membrane reactor processes. However, in order to fully exploit the unique properties of these advanced ceramics, the ceramic membranes must be sealed to a dense ceramic or a metal support structure. Commonly used seals are not suitable for these applications because their heat resistance is ineffective above 400ºC. Therefore, grant applications are sought to develop inorganic materials with high melting points that can be used for sealing the ceramic membranes at high temperatures (greater than 600ºC). For good sealing results, the seals must be tailored to obtain suitable wettability, viscosity, chemical inertness, thermal expansibility, and bonding strength. The sealing of these ceramic membranes should achieve a success rate of nearly 100% if correct sealing procedures were adopted.

Grant applications also are sought to develop materials for joining ceramic and metal parts in newly-developed hydrogen gas separation membranes, which also operate at high temperatures. This high temperature 'glue' would replace materials used at lower temperatures. Approaches of interest should focus on new strategies and materials, and should include an evaluation of the strength and chemical properties of the new materials.

Questions - contact Richard Dunst (Richard.dunst@netl.doe.gov)

c. Computer-Aided Development of New Materials for Energy Conversion from Coal—Novel materials that can withstand high temperatures and extreme environments are dominant themes in materials development for efficient energy systems. Basic requirements are elevated melting temperatures, high oxidation and corrosion resistance, the ability to resist creep, and high toughness. An effective way to accelerate research in this field is to use advances in materials simulations and in high performance computing and communications to guide experiments. This synergy between experiment and advanced materials modeling would significantly enhance the synthesis of novel high-temperature materials. The use of computer simulation to study the structure, properties, and processing of materials on the atomic scale could replace traditional, trial-and-error experimental methods, which are costly and time-consuming. A wide range of computer modeling tools – ranging from highly accurate quantum mechanics (electronic structure) methods to simple interatomic potentials, along with databases to support the models – could be brought to bear on addressing critical materials needs.

Grant applications are sought for the development of computational tools and simulations that will reliably predict properties of materials for fossil energy systems in advance of fabrication. Grant applications should (1) focus on the development new materials with high performance potential that have not been previously considered or identified for fossil energy applications, and (2) address the key viability indicators for these new material concepts: reliability of performance, fabricability, and affordability. Approaches leading to step improvements in the performance of existing materials are not of interest and will be declined.

Questions - contact Patricia Rawls (patricia.rawls@netl.doe.gov)

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Subtopic a: Surface Modification of Alloys for Ultrasupercritical Coal-Fired Boilers

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)

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)

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)

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: Sealing Technology for Gas Separation Devices

Weil, S, et al., Development of Brazing Technology for Use in High-Temperature Gas Separation Equipment, 2003.(Full text available at: http://www.netl.doe.gov/publications/proceedings/03/materials/manuscripts/Weil_m.pdf)

Ritland M. A. and Readey, D. W., "Processing and Properties of Al2O3-Cu Composites," Proceedings of the 1993 TMS (The Minerals, Metals and Materials Society) Fall Meeting: Processing and Fabrication of Advanced Materials III, pp. 3-13, TMS, August 1994. (ISBN: 0873392310)

Ritland, M. A., et al., "Method for Sealing and/or Joining an End of a Ceramic Filter," June 2001. (U.S. Patent No. 6,247,221) (Full text available at: http://www.uspto.gov/. Under "Patents" on menu at left, click on "Search". Under "Issued Patents" click on "Quick Search". Search by Patent No. above.)

Hardy, J. S., et al., "Joining Mixed Conducting Oxides Using an Air-Fired Electrically Conductive Braze," Journal of the Electrochemical Society, 151(8): J43-J49, 2004. (ISSN: 0013-4651)

Please refer to the NETL website for additional information on sealing technologies for gas separation devices (www.netl.doe.gov)

Subtopic c. Computer-Aided Development of Novel New Materials for Energy Conversion from Coal

Chan, K. S. and Davidson, D. L. “Improving the Fracture Toughness of Constituent Phases and Nb-Based In-Situ Composites by a Computational Alloy Design Approach,” Metallurgical and Materials Transactions A, 34A: 833–1849, 2003. (ISSN: 1073-5623)

Garberoglio, G., et al., “Adsorption of Gases in Metal Organic Materials: Comparisons of Simulations and Experiments,” Journal of Physical Chemistry B, 109(27): 13094-13103, 2005. (ISSN: 1089-5647)

OFFICE OF HIGH ENERGY PHYSICS

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

The DOE supports the development of advanced electronics and 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, high speed logic arrays, and fiber optic links useful to HEP experiments and particle accelerators. Grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities.

Although particle physics detector and data processing instrumentation typically are developed in large collaborative efforts at national particle accelerator centers, there are efforts where small businesses can make innovative and creative contributions. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. 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. Special Purpose Chips and Devices for Large Particle Detectors—Grant applications are sought to develop special purpose chips and devices for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, 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.

Questions - contact Donald Petravick (Don.Petravick@science.doe.gov)

b. Circuits and Systems for Processing Data from Particle Detectors—Grant applications are sought to develop circuits and systems for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, pixilated imaging sensors, particle calorimeters, 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.

Questions - contact Donald Petravick (Don.Petravick@science.doe.gov)

c. Systems for Data Analysis and Transmission—Grant applications are sought to develop advanced high-speed logic arrays and microprocessor systems for fast event identification, event trigger generation, 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).

Grant applications also are sought for the innovative use of fiber optic links and/or commodity high-bandwidth networks for high-rate transmission of collected data between particle detectors and data recording or control systems. Approaches of interest should demonstrate technologies that feature one or more of the following characteristics: low noise, radiation tolerance, low power consumption, high packing density, and the ability to handle a large number of channels at very high rates.

Questions - contact Donald Petravick (Don.Petravick@science.doe.gov)

d. Enhancements to Standard Interconnection Systems—Much of the electronics instrumentation in use in HEP is packaged in one of the international module interconnection standards (e.g., VMEbus, PCIExpress, or high speed serial interfaces). Grant applications are sought to develop (1) new modules that will provide capabilities not previously available; (2) technology to substantially enhance the performance of existing types of modules; and (3) 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 Donald Petravick (Don.Petravick@science.doe.gov)

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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)

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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)

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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.gov/

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. Circuit oriented high performance networking (http://www.perfsonar.net/)

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 '08 Workshop Recommended Reading list: http://phystat-lhc.web.cern.ch/phystat-lhc/2008-001.pdf)

18. "CHEP'07 [Computing in High Energy Physics Conference]," Victoria, BC< canada, Sept. 2-4, 2007, Website. (Website, including Conference papers http://www.chep2007.com/)

19. Open Science Grid Website. (URL: http://opensciencegrid.org)

34. HIGH ENERGY PHYSICS COMPUTER TECHNOLOGY

The DOE supports the development of computational technologies essential to experiments and particle accelerators used for High Energy Physics (HEP) research. Areas of present interest include 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 computer systems 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. 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. Large Scale Computer Systems—Grant applications are sought to develop (1) improvements to the wide area network fabric used by the experimental HEP community; (2) improvements to the reliability of cybersecurity systems protecting distributed storage and job management systems; and/or (3) improvements to the reliability and performance of data systems for HEP, which include permanent and temporary storage approaching exabyte scale. Proposed efforts must address identified computing problems related to diverse, large scale computing systems that support particle physics data processing and analysis.

Questions - contact Donald Petravick (Don.Petravick@science.doe.gov)

b. Computational Methods 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 [19] aim to enable a federated computing model for HEP and other participating disciplines. Grant applications are sought to support the design, implementation, and operation of distributed computing systems comprising many distributed Petaflops 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.

Questions - contact Donald Petravick (Don.Petravick@science.doe.gov)

c. Software to Support Collaborations of Dispersed Researchers—Grant applications are sought to develop advanced software 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. Areas of interest include (1) software project management tools; (2) visualization and software environments appropriate for physics analysis; (3) software to support data systems distributed over a wide area network; (4) 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; (5) algorithms and software tools for pattern recognition and optimization of data analysis; and (6) tools for improvements to the performance, verification, or validation of large software codes, such as found in the LHC experiments.

Questions - contact Donald Petravick (Don.Petravick@science.doe.gov)

d. Web Tools and Associated Infrastructure to Support Collaborations—Grant applications are sought to develop advanced advanced web tools and associated infrastructure technologies to strengthen the ability of dispersed particle physics researchers to collaborate. Areas of interest include (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) computer system components and supporting software incorporating the use of Quality of Service features generally available in wide area networks; (3) 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; (4) 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; (5) web tools for remote data selection ("skimming");

Questions - contact Donald Petravick (Don.Petravick@science.doe.gov)

e. 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 Donald Petravick (Don.Petravick@science.doe.gov)

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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).

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13. Circuit oriented high performance networking (http:www.perfsonar.net/)

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16. "GGF Document Series," Global Grid Forum published documents. (URL: http://sourceforge.net/projects/ggf)

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18. "CHEP'07 [Computing in High Energy Physics Conference]," Victoria, BC< canada, Sept. 2-4, 2007, Website. (Website, including Conference papers at: http://www.chep2007.com/)

19. Open Science Grid Website. (URL: http://opensciencegrid.org)

35. 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. Devices that exhibit insensitivity to very high radiation levels have recently become extremely important. Grant applications must clearly and specifically indicate their particular relevance to HEP programmatic activities.

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. 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 Howard Nicholson (howard.nicholson@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 Howard Nicholson (howard.nicholson@science.doe.gov)

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36. 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 Superconducting Wire Technologies for Magnets—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 50 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 multi-filamentary 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 (1 km minimum length) for winding and testing in small dipole or quadrupole magnets.

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 lead and current distribution systems, based on high-temperature superconductors, for application to superconducting accelerator magnets – requirements include an operating current level of 5 kA or greater, stability, low heat leak, and good quench performance; (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 (including open midplane magnest as needed in Muon Collider design); (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; (6)

improved cryostat and cryogenic techniques; or (7) fast cycling HTS magnets capable of operation at or above 4T/s.

Questions - contact Bruce Strauss (bruce.strauss@science.doe.gov)

c. Starting Raw materials and Basic Superconducting Materials— High performance niobium-titanium (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.

Present wires made of magnesium diboride (MgB_2) and its alloyed variants 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 multi-filamentary 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.

Lastly, grant applications are sought to develop (1) 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; and (2) 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.

Questions - contact Bruce Strauss (bruce.strauss@science.doe.gov)

d. Ancillary Technologies for Superconductors—Grant applications also are sought to develop innovative wire and cable design and processing technologies. Approaches 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; and technologies to improve wire piece length and increase billet mass.

Grant applications also are sought for innovative insulating materials that are compatible with the use of inter-metallic superconductors in practical devices. Approaches of interest should enable the use of inter-metallic 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.

Lastly, grant applications are sought to develop HTS conductors suitable for the very-high-field 30-50 T solenoids needed for final ionization cooling stages of a Muon Collider.

Questions - contact Bruce Strauss (bruce.strauss@science.doe.gov)

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* Abstracts and ordering information available at:
http://proceedings.aip.org/proceedings/

37. 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 500-1000 GeV superconducting linear electron-positron collider, that will probe the energy frontier with unprecedented precision (see reference 1). Grant applications submitted in response to this topic must explicitly describe the relevance of the proposed technology to the ILC. Proposed approaches must demonstrate an awareness of ILC linac parameters, which 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. **Grant applications are sought only in the following subtopics.**

a. Superconducting Radiofrequency Cavities—Grant applications are sought 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.

Grant applications also are sought 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.

Questions - contact LK Len (lk.len@science.doe.gov)

b. Instrumentation for SRF Cavities—Grant applications are sought 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.

Grant applications also are sought 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° 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.

Grant applications also are sought 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). Additional ILC parameters can be found in the introduction to this topic.

Lastly, grant applications are sought 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.

Questions - contact LK Len (lk.len@science.doe.gov)

c. Cryogenic and Refrigeration Technology for SRF Systems—The ILC is based on the cold (superconducting) technology requiring a large cryogenic system. Grant applications are sought for research and development leading to the design and fabrication of ILC cryomodules for 1.3 GHz superconducting cavity strings. Each ILC cryomodule contains eight or nine1.3 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.

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

Questions – contact LK Len (lk.len@science.doe.gov)

d. Beam Instrumentation and Feedback Systems—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, which are listed in the introduction to this topic.

(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, which are listed in the introduction to this topic.

(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, which are listed in the introduction to this topic. The emittance should be measured with an accuracy of 10% or better.

(4) particle beam 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)

e. Undulators—The ILC uses undulators to generate the photons that subsequently impinge on a thin target to produce positrons. Grant applications are sought to develop short-period helical undulators, suitable for use with a high-energy (>150 GeV) electron beam, to produce an intense 10 MeV photon beam. The undulator field, gap, and period must be consistent with the requirements of the ILC undulator-based source (reference 2). ILC parameters are listed in the introduction to this topic.

Questions – contact LK Len (lk.len@science.doe.gov)

f. 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 ~1 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 6 MHz for a duration of up to 1 ms, at a repetition rate of 5 Hz.

(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 3).

(5) water cooled accelerator magnets with extremely high reliability, characterized by a mean time to failure greater than 10 million hours. These accelerator magnets also require highly reliable power supply systems with a mean time to failure greater than 4 million hours, and high-reliability electronic control systems for magnet operation.

Questions – contact LK Len (lk.len@science.doe.gov)

g. Polarized RF Photocathode Sources—Grant applications are sought for the development of polarized electron sources that 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, which can be found in the introduction to this topic.

Questions – contact LK Len (lk.len@science.doe.gov)

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38. 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. As high energy physics facilities get bigger and more costly, the DOE HEP program seeks to develop advanced technologies that can be used to reduce the overall machine size and cost. **Grant applications are sought only in the following subtopics.** (Relevance to applications in HEP must be explicitly described in the submitted grant applications.)

a. Advanced Accelerator Concepts and Modeling—Grant applications are sought to develop new or improved accelerator designs that can provide very high gradient (>200 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 also are 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.

Questions – contact LK Len (lk.len@science.doe.gov)

b. Technology for Muon Colliders and Muon Beams—Grant applications 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) new concepts for the generation, capture, acceleration, and colliding of intense muon beams; (2) concepts or devices for ionization cooling, including emittance exchange processes; (3) improved simulation packages for studying ionization cooling of muon beams; (4) novel cooling schemes of optical stochastic cooling, coherent electron cooling, and paramteric ionization cooling; (5) concepts or devices for manipulation and control of the longitudinal phase space of large emittance muon beams, including bunching, phase rotation, and bunch merging; (6) concepts or devices for producing intense polarized muon beams; (7) large aperture kickers for injection and extraction in muon cooling rings; (8) concepts and prototyping elements for cost effective rapid acceleration, e.g., 1 T/s pulsed magnets; (9) instrumentation for muon cooling channels that have muon intensities of 10^{12} muons/pulse; or (10) 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).

Grant applications are also 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.

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. Novel Device and Instrumentation Development—Grant applications are sought for the development of electromagnetic, permanent magnet, silicon microcircuit, or electron-beam-based charged particle optical elements for particle beam focusing. Examples include, but are not limited to, (1) dipoles, quadrupoles, higher order multipole correctors for use in electron linear accelerators; and (2) 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.

Grant applications also are sought to develop (1) undulators for bunching high energy electron beams, needed for phased injection in high frequency accelerating structures and for generating coherent transition radiation; (2) electron lenses for compensation of space-charge and beam-beam effects and for particle collimation; (3) 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; and (4) 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).

Grant applications also are sought to develop achromatic, isochronous compact focusing systems with broad energy acceptance and compact broadband (10-100 MeV) spectrometers, suitable for use in laser acceleration experiments.

Lastly, 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.

Questions – contact LK Len (lk.len@science.doe.gov)

d. Laser Technology for Accelerators—Lasers are used in many areas of accelerator applications, ranging from plasma channel formation to laser wakefield acceleration. Grant applications are sought to develop lasers for laser-accelerator applications that provide substantial improvements over currently available lasers in one or more of the following parameters: (1) longer wavelengths (up to 2 to 2.5 μm for use with Si transmissive optics), (2) very short wavelengths (< 200 nm) with low mode numbers (M-squared < 100) and high pulse energy (> 0.1 J) for photo-ionized plasma sources, (3) higher power, (4) higher repetition rates, and (5) shorter pulse widths.

Questions - contact LK Len (lk.len@science.doe.gov)

e. Inexpensive High Quality Electron Sources—Grant applications are sought for the design and prototype fabrication of small, inexpensive 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 <5π mm-mrad; and (3) pulse repetition rate >10 Hz. Grant applications also are 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; (2) laser or electron driven systems for such guns; and (3) electron beam sources, such as sheet or multiple beams, relevant to the abovementioned high power RF applications.

Questions - contact LK Len (lk.len@science.doe.gov)

f. Hardware and Software Solutions for Accelerator Control—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 also are 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)

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

Grant applications also are 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)

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39. RADIO FREQUENCY ACCELERATOR TECHNOLOGY FOR HIGH ENERGY ACCELERATORS AND COLLIDERS

Radio frequency (RF) technology is a key technology common to all high energy accelerators. RF sources with improved efficiency and accelerating structures with increased accelerating gradient are important for keeping the cost down for future machines. Relevance to applications in HEP must be explicitly described. **Grant applications are sought only in the following subtopics.**

a. New Concepts and Modeling Techniques for 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 also are sought to develop simulation tools for modeling high-gradient structures, in order to predict such experimental phenomena as the onset of breakdown, post breakdown phenomena, and the damage threshold. Specific areas of interest include 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.

Questions - contact LK Len (lk.len@science.doe.gov)

b. Materials and Fabrication Technologies for SRF Cavities—Material properties, surface dynamics, processing procedures, and geometric configurations can have significant impact on the performance of the accelerator cavities. Grant applications are sought to develop (1) new materials that are suitable for the fabrication of superconducting radiofrequency (SRF) cavities, such as large grain or single crystal Nb; (2) new or improved SRF cavity fabrication techniques especially weld-free approaches, and (3) improved understanding and performance of SRF cavities.

Questions - contact LK Len (lk.len@science.doe.gov)

c. Radio Frequency Power Sources and Components—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 100 Hz) pulsed X-band 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.

The next generation of multi-TeV linear colliders will require many RF power handling components which have not been fully developed, 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 high peak powers (for example, greater than 300 MW) and pulse widths of approximately 300 nanoseconds at X-band. 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.

Questions - contact LK Len (lk.len@science.doe.gov)

d. Modulators for Pulsed Radio Frequency Systems—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 100 kV – 1 MV range for driving currents of 0.1 – 1 kA, with pulse lengths of 0.2 – 5.0 μs, and with rise- and fall-times that are ~10% of the pulse length or less. 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.

Questions - contact LK Len (lk.len@science.doe.gov)

e. Switching Technology for Pulsed Power Applications— 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.

Grant applications are 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 (0.1-10 kA) at voltage levels of up to 20 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%).

Questions - contact LK Len (lk.len@science.doe.gov)

f. Energy Storage for Pulsed Power Systems—High reliability, high-energy-density energy storage capacitors are a key component for the development of reliable solid state pulsed power systems. Grant applications are sought to develop and optimize storage capacitors that can: (1) deliver high peak pulse current (0.1-10 kA) in the partial discharge region (less than 30 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); (3) be packaged to meet the requirements of high power solid state board layouts and have minimum production cost; and (4) have an accurately known lifetime of tens of thousands of hours.

Questions - contact LK Len (lk.len@science.doe.gov)

g. Deflecting Cavities (AKA "crab cavities") for Luminosity Enhancement in Colliders—High luminosity colliders can benefit from the use of a crossing angle between the colliding beams. The crossing angle will provide a larger luminosity gain if the particle bunches are tilted, resulting in what is called a "crab crossing." Grant applications are sought for the development of crab cavities for the LHC and for the ILC. Approaches of interest, which may include new cavity geometries, should include the demonstration of high-performance prototype superconducting crab cavities. Grant applications also are sought for ancillary technology for use with crab cavities, including the development of (1) fundamental power couplers; (2) high-order, same-order, and low-order mode damping couplers, including design, analysis, and low-power testing; and (3) conceptual and detailed designs for low-cost crab cavity cryomodules and tuners.

Questions - contact LK Len (lk.len@science.doe.gov)

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OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH

40. IMAGING, RADIOCHEMISTRY, AND ARTIFICIAL RETINA

The Department of Energy is interested in innovative research involving imaging and radiochemistry technologies. Principles of physics, chemistry, and engineering are being employed to advance fundamental concepts that will contribute to the Department of Energy's energy and environmental research and to the broad needs of the medical community.

The DOE Imaging, Radiochemistry, and Artificial Retina programs covers a broad range of energy-related technologies, including radiochemistry and advanced imaging instrumentation. With respect to radiochemistry, 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 develop innovative hermetic packaging materials/methods for integrated microelectronic systems.

Grant applications are sought only in the following subtopics:

a. Radiochemistry—Grant applications are sought to develop new techniques for radiolabeling of molecular probes of biological importance. These new labeling techniques can be applicable to molecular probes for either positron emission tomography (PET) or single photon emission computed tomography (SPECT) imaging. Areas of interest include the development of techniques that (1) approach theoretical maximum for specific activity and (2) protect the probe from auto-radiolysis *in vitro* and *in vivo*.

Grant applications also are sought to develop techniques for linking a radionuclide label with an additional imaging label (e.g., two different radionuclides, or one fluorescent- and one radio-label) at two different sites of the same molecular probe. Proposed dual-labeling methodologies should allow for simultaneous quantitative assessment of two different biochemical reactions that reflect either two different functional characteristics or a combination of structural and functional information. The quantitative assessments could be achieved through the use of multimodality/hybrid instruments – such as PET/MRI or SPECT/MRI, PET/CT or SPECT/CT, and either PET or SPECT combined with an optical detector system. Research proposals should (1) describe methodologies for quantitative measurement of *in situ* chemical reactions, as well as the effects of perturbations of these chemical reactions, relative to internal and external stimuli in animal models, and (2) enable imaging capabilities to visualize plant and microbial metabolic networks and interactions with the environment.

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 in living systems, 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.; (4) methods of integrating *in vitro* and *in vivo* imaging instrumentation technologies for real time radionuclide-based molecular imaging of biological function; and (5) new radionuclide imaging techniques in animals, for enhancing drug development.

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

c. Hermetic Packaging for Artificial Retina Integrated Microelectronic Systems— Electronic medical devices that are implanted in the eye as part of the Artificial Retina Project must operate under harsh conditions. Corrosion in the saline environment is a particular concern, because body temperature (versus room temperature) will accelerate degradation processes. Microelectronic implants can fail within hours if not protected properly. Implantable, microelectronic systems will require not only packaging to protect the microelectronics but also a mechanism for feed-through across the packaging. Therefore, grant applications are sought to develop innovative hermetic packaging materials/methods for integrated microelectronic systems. Approaches of interest must:

- be suitable for implantation in the eye as part of the Artificial Retina Project
- be biocompatible to ISO 10993
- integrate with the microelectronics
- permit the population of the package interior
- a final sealing temperature within the acceptable limits of the electronics and materials used
- provide a feed-through density of 270 or more, with special consideration for expansion to 1000 distinct points
- fit between a TO-39 to TO-8 header
- protect a microelectronic chip for at least 10 years at body temperature
- withstand conventional sterilization (ETO or radiation)
- withstand implantation surgery (gripped by forceps)
- integrate with thin film electrode array technology
- be compatible with MRI , X-ray, and CT
- have reproducible qualities

In addition, grant applications must (1) specify the thermal properties of the materials used, and (2) address manufacturability, testing, and certification issues associated with the development of a suitable implantable hermetic package.

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41. 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. 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. Therefore 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 perennials), and (2) more efficient DNA transformation of cogent microbes, particularly archaebacteria.

b. 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 instruments with analytical capabilities to reveal the differing functional roles in biofilms with depth and to identify 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 experimental enclosures with complementary instrumentation for performing cloning and processing of strict anaerobes, including biochemical assays that can be performed without the destruction of oxygen-sensitive enzymes.

c. Instrumentation for Dynamical Analysis of Lignocellulose Processing — Processing of lignocellulosic material by microbes will be a major step in both biomass deconstruction and downstream production of both ethanol and second generation biofuels. The optimal utilization of input feedstocks will depend on the dynamic measurements of constituents during processing, so that real time adjustment and management is feasible. Therefore, grant applications are sought to develop instrumentation systems that will rapidly quantitate constituents (including microbes, residual solids, and digestion products) in both aqueous and semi-solid slurry phases of lignocellulose reactors and coupled fermenters.

d. Dueterated Macromolecule Resources—The cultivation of source organisms on dueterated media is necessary for the optimal application of neutron imaging or scattering techniques to biological materials. Although cogent growth resources are available for such long-used hosts as *Escherichia coli*, suitable standardized media and techniques for the cultivation of other bacteria of interest (e.g., the yeast *Saccharomyces* and other eukaryotes) are either not yet robust or adequately reliable. Therefore, grant applications are sought to develop improved cultivation resources for such hosts. The dueterated target products of interest are components of lignocellulosic biomass and sterols.

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

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42. 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.

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 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/orifrc/index.html); Old Rifle, CO (http://ifcrifle.pnl.gov/); and Hanford, WA (http://ifchanford.pnl.gov/). At 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, geochemical or hydrogeological methods to: (1) characterize subsurface properties that control the transport and dispersion of contaminants in groundwater and the unsaturated zone, or (2) monitor dynamic processes such as fluid flow, contaminant transport, and geochemical and microbial activity in the subsurface. While subsurface 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 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-90, mercury, uranium, iodine-129, plutonium, americium, cesium-137, and cobalt. The ability to distinguish between the relevant oxidation states of these elements and their chemical species is of particular concern. 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, micro-sensors, solar power cells, etc.) 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)

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43. 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 contemporary terrestrial carbon sinks, the sensitivity of climate to atmospheric CO_2, and future potentials for sequestration of carbon in terrestrial systems. Therefore, improved measurement approaches are needed to quantify CO_2 changes of atmospheric components of the global carbon cycle, and to understand processes and mechanisms of carbon sequestration of the terrestrial biosphere. There is also interest in innovative approaches for flux and concentration measurements of methane and other greenhouse gas constituents associated with terrestrial systems.

The "First State of the Carbon Cycle Report (SOCCR)" (Reference 1) provides rough estimates of terrestrial carbon sinks for North America. A DOE working paper on carbon sequestration science and technology (Reference 2) also describes research needs and technology requirements for sequestering carbon by terrestrial systems. Both documents call for advanced sensor technology and measurement approaches for detecting changes of atmospheric CO_2 properties and of carbon quantities of terrestrial systems (including biotic, microbial, and soil components). Such measurement technology would improve the quantification of CO_2 and carbon stock and flux measurements of major sinks identified by the SOCCR report (see Figure ES.1 therein).

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 balloon 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 methane within the atmospheric and terrestrial components of the global carbon cycle. 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 and its isotopes; and high accuracy and precision measurement of other trace greenhouse gases.

(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 also are 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. Instrument designs should (1) place emphasis on determining the sources and sinks of carbon, CO, and trace species, and (2) ensure long-term and robust field deployment. Grant applications dealing with the remote measurement of vascular plant properties and processes will be considered, provided that they meet the requirements described below.

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. Approaches that develop unique surface-based observations and use these observations for the calibration/interpretation of other remotely derived data are of interest. Also of interest are potential applications of CO_2 sensors via ballonsonde; however, 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)

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44. 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 Fourth Assessment Report of the Intergovernmental Panel on Climate Change examined the effect of changes in clouds and aerosols on the Earth's energy balance. 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. Stabilizer Platforms for Radiometers—The Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) pursues accurate measurements of atmospheric radiation through its Aerial Vehicle Program (AVP). The ability to measure atmospheric radiation while in flight is a valuable capability for atmospheric research. These measurements complement satellite and ground station measurements in providing increased certainty in vertical column radiometric information, in order to aid in understanding climate forcing.

The sensitive instruments used to make these measurements require inertially-stabilized platforms. Such platforms are used to stabilize a broad array of sensors related to weapons systems, cameras, and telescopes. However no such platform is compatible with the light aircraft that are likely to serve as the vehicle for the bulk of these measurements. Measurements of solar and infrared irradiance by instruments rigidly mounted to an aircraft have historically been plagued by the introduction of offsets and fluctuations into the data that are solely due to pitch and roll movements of the aircraft. Therefore, grant applications are sought to develop a stabilization system that is compatible with light aircraft.

The platform must meet the following specifications: (1) contain radiometer and possibly other instruments that are positioned vertically while in flight; (2) the radiometers should have a maximum weight of 10 kilograms in which the combined weight of the radiometers or comparable instruments in shape and weight. The total weight of the stabilization system and instruments should not exceed 30 kilograms. The system must provide 2 axes of pitch and roll stabilization. The range of correction will be limited to 15 degrees of roll and pitch, with a pitch rate of 10 degrees per second and a roll rate of 10 degrees per second. The leveling accuracy of 0.05 degrees is required, but 0.02 is desirable.

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

b. Oxygen-Band Spectrometer—Both simulations and short-field deployments using the oxygen "A" and "gamma" bands have demonstrated that the path-length distribution of solar photons, and especially the moments of this distribution, respond strongly to variations in the opacity and spatial distribution of clouds in both the vertical and horizontal directions. Conversely, the moments of the path-length distribution can be used both to infer cloud properties and to diagnose the process of absorption of shortwave radiation by greenhouse gases in the presence of complex cloudiness. Ground-based differential absorption spectrometry of molecular oxygen could be used to infer the most meaningful moments (mean, variance, etc.) of the path-length distribution of solar photons from the top of the atmosphere to the sensor, provided that the resolution is sufficiently high. Therefore, grant applications are sought to develop robust, field-worthy oxygen-band spectrometers capable of accurately measuring the first three moments of the photon path-length distribution. These spectrometers would be deployed by the DOE's Atmospheric Radiation Measurement (ARM) Program in support of its observational climate science mission.

For an A-band instrument, the following specifications apply: (1) wavenumber resolution should be 2-4 cm^{-1}; (2) wavelength stability should be 1/20 FWHM or better; (3) At a given resolution, the number of independent pieces of path-length information that can be accurately inferred depends strongly on the out-of-band rejection of the slit function which should not exceed $3x10^{-4}$); (4) instrument operation with a zenith-pointing narrow field-of-view (a few degrees), with an option for a hemispherical field-of-view as well; and (5) signal-to-noise ratio should exceed 100:1 at the darkest wavelength, with integration times on the order of a minute. Applicants will be expected to coordinate with the ARM Science Team's A-band Focus Group to be sure the science requirements are met.

Comment [RP1]: This is unitless.

Designs based on other solar spectral bands of oxygen can be considered as long as they perform as well in terms of information content and accuracy of the photon path-length. For all spectral bands, a fieldable instrument will have to operate reliably and autonomously under any weather condition. Applicants will be expected to work closely with the ARM Program to refine the requirements listed above and to arrange for field tests of the instrument at ARM sites.

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

c. Measurements of the Chemical Composition of Atmospheric Aerosols—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).

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;

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 the Chemical Composition of Atmospheric Aerosol Precursors
In order to better understand the evolution of aerosols in clouds as well as open air, 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. Of special interest are volatile organic compounds (VOC) and intermediate volatility organic compounds (IVOC). In general, VOCs and IVOCs partition primarily into the gas phase; however, they may react with gaseous oxidants or with existing aerosol particles and droplets to form secondary organic aerosol (SOA)

mass. Current methods for predicting SOA production rates, based only on precursor organic compounds that have been quantified (both VOCs and oxygenates), underestimate SOA production by factors of 3 or more. One problem is that many gaseous organic compounds are not detected by commonly-used techniques, such as gas chromatographic or chemical ionization-mass spectrometric methods. Therefore, grant applications are sought to develop instruments to determine the total amount of organic compounds as total carbon. The data provided by these instruments would allow scientific insights to be gained regarding the reason for the underestimation of SOA production – i.e., is the underestimation due to key precursors that are not measured, or is it due to the use of extrapolations (from laboratory kinetic and equilibrium data) that were not appropriate for ambient conditions? Thus total carbon measurements would be of value in addition to the ongoing need to accurately quantify compounds or compound classes in the volatility ranges discussed above. Grant applications are sought to develop instruments for both these needs. Of special interest are instruments with reduced weight and fast response time, which would make them suitable for sampling from airborne platforms.

Grant applications also are sought to develop improved measurements of inorganic aerosol precursors. Examples of compounds of interest (with desirable detection limits and response rates listed in parenthesis) include are gaseous HNO_3 (0.1 ppbv, 1 Hz), O_3 (2-3 ppbv, 10 Hz), and SO_2 (5 pptv, 1 Hz). Instruments suitable for sampling from airborne platforms (that is, with reduced weight and power requirements, high sensitivity, and fast response time) would be of particular interest.

In addition to the free-air measurements described above, grant applications are sought to develop instruments or instrument systems for measuring aerosol precursors in cloud droplets. Such systems must address methods for the efficient sampling of droplets as well as a mechanism for transferring the sample to the appropriate analytical instrumentation in which the organic or inorganic target analytes are measured. Of particular interest are systems that separate or discriminate between interstitial compounds and those that occur dissolved or suspended within cloud droplets.

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

e. 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 0.1 - 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.

Grant applications also are sought to develop fast (~ 1 sec) and lightweight (suitable for sampling from airborne platforms) instruments for particle size spectrum measurements in the 10- 600 nm size range or for cloud droplet/drizzle measurements (10–1000 µm size range). A related airborne measurement of great interest is a fast cloud condensation nuclei spectrometer for supersaturation ranges of the order 0.02% – 1%.

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

f. Aerosol Scattering and Absorption (*in situ*)—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.

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

g. Aerosol Scattering Coefficient and Phase Function —(remote). 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 Rickey Petty at: (rick.petty@science.doe.gov)

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45. ENHANCED AVAILABILITY OF CLIMATE MODEL OUTPUT

Much of the nearly $2 billion U.S. annual research budget for climate change supports grants from the Department of Energy, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and National Science Foundation (NSF). The simulations of long-term climate change, which result from the federally-funded research, are a valuable resource, and, accordingly, these agencies have made every effort to provide efficient means of sharing the output data from the modeling efforts with the research community. For example, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) (http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php) makes available a subset of multi-model output from the Intergovernmental Panel for Climate Change (IPCC) to researchers for non-commercial purposes only. However, there has been increasing pressure from users other than the research community for access to the multi-model output, including those users that intend to use the data for commercial purposes.

a. Accessibility of Climate Model Data to Non-Researchers—The purpose of this subtopic is to broaden the usage of federally-funded, long-term climate change simulations of high-end climate models, such as the Community Climate System Model, the NOAA Geophysical Fluid Dynamics Laboratory model, and the NASA Goddard Institute for Space Studies model. Grant applications are sought to develop technology for making the output of these models more accessible to a variety of potential users. Approaches of interest include the development of (1) preferred data formats for users of climate model output in particular applications (e.g., agriculture, water resources, energy); (2) resources required to convert from existing data formats to formats required by users in the various application communities; and (3) improved software frameworks and prototypes for data access by distinct application communities. Applicants would be expected to document lessons learned in the experience of providing climate model output data to the non-research community.

Questions – contact Anjuli Bamzai at: (Anjuli.Bamzai@science.doe.gov)

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OFFICE OF NUCLEAR PHYSICS

46. 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 (FRIB). 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 or piezoelectric cavity tuning mechanisms; (2) fast ferroelectric microwave components that control reactive power for fast tuning of cavities or fast control of input power coupling; (3) 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; (4) innovative designs for hermetically sealed helium refrigerators and other cryogenic equipment, which simplify procedures and reduce costs associated with repair and modification; (5) more cost effective, kW-to-multiple-kW level, liquid helium refrigerators; (6) 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; and (7) alternative cavity fabrication techniques, such as hydroforming or spinning of seamless SRF cavities. Potential applicants interested in items (1) through (7) above should contact Dr. Robert Rimmer at Thomas Jefferson Laboratory (rarimmer@jlab.org).

Grant applications also are sought to develop (8) methods for manufacturing superconducting radio-frequency (SRF) (>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; and (9) advanced fabrication methods for elliptical SRF cavities to reduce production costs (industrial metal forming techniques, especially with large grain or ingot material, have the potential for significant cost reductions by simplifying the sub-assemblies – e.g., dumbbells and beam tube – and reducing the number of electron beam welds).

Grant applications also are sought to develop (10) improved superconducting materials that have lower RF losses, operate at higher temperatures, and/or have higher RF critical fields than sheet niobium; and (11) 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. Approaches of interest for items (10) and (11) should identify appropriate precursors and create high quality Nb, NbN, Nb_3Sn, or MgB_2 films with anti-diffusion dielectric overlayer via atomic layer deposition (ALD) synthesis.

Finally, grant applications are sought to develop (12) advanced techniques for surface processing of superconducting resonators, including methods for electropolishing, high temperature treatments, and surface coatings that enhance or stabilize performance parameters. Surface conditioning processes of interest should yield microscopically smooth ($R_q < 10$ nm / 10μm^2), crystallographically clean bulk niobium surfaces; and/or reliably remove essentially all surface particulate contaminates > 0.1 µm from interior surfaces of typical RF accelerating structures. Also, grant applications are sought for laser surface glazing of niobium for surface purification and annealing in UHV.

Potential applicants interested in items (8) through (12) above should contact Dr. Charles Reece at Thomas Jefferson Laboratory (reece@jlab.org).

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

b. Radio Frequency Power Sources—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 (benzvi@bnl.gov), or Dr. Jerry Nolen at Argonne National Laboratory (nolen@ANL.gov) for further specifications.

Grant applications are also sought for a microwave power device, klystron or IOT offering improved efficiency (55-60%) while delivering up to 8 kW CW at 1497 MHz. The device must provide a high degree of backwards compatibility both in size and voltage requirements to allow its use as a replacement for the klystron (model VKL7811) presently used at Thomas Jefferson Laboratory, while providing significant energy savings. For more detail contact Rick Nelson at Thomas Jefferson Laboratory (nelson@jlab.org).

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

c. 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 (1^{o} or less of phase and 0.1% amplitude) and electron acceleration structures (0.1^{o} 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; and (7) multi-cell superconducting deflecting RF structures with sufficient higher order mode damping, for use as crab cavities for protons and ions in an electron ion collider.

Grant applications also are sought to develop software for the design and modeling of the above systems. 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. Also of interest are advanced parallel-computing simulation techniques for the optimization of both normal- and super-conducting accelerating structures for the future rare isotope facility. Applicants interested in software design and modeling should contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov).

Finally, 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.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

d. 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) techniques for *in situ* beam pipe surface coating to reduce the ohmic resistance and/or secondary electron yield; and (8) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients.

With respect to polarizing sources, grant applications are sought to develop (9) polarized hydrogen and deuterium (H-/D-) sources with polarization above 90%; (10) cw polarized electron sources delivering beams of ~10 mA, with longitudinal polarization greater than 80%; (11) ~28 MHz cw polarized sources delivering beams of ~500 mA with polarization greater than 80%; and (12) 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. For questions related to polarized electron sources, potential applicants should contact Dr. M. Poelker at Thomas Jefferson Laboratory (poelker@jlab.org).

Grant applications also are sought to develop (13) methods to improve high voltage stand-off and reduce field emission from high voltage electrodes, compatible with ultra-high-vacuum environments; (14) 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; (15) 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 (16) a cost-effective means to obtain and measure vacuum below 10^{-12} Torr.

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 _48__, Nuclear Physics Detection Systems, Instrumentation and Techniques.)

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 ^3He; and (4) sophisticated computer software for tracking spin polarized particles in storage rings and colliders.

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. Potential applicants interested in FFAG 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. Areas of interest include intra-beam scattering, spin dynamics, polarized beam generation including modeling of cathode geometries for high current polarized electron sources, 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 (benzvi@bnl.gov).

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

e. Accelerator Control and Diagnostics—Grant applications are sought to develop (1) 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); (2) 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); (3) 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; (4) beam diagnostics for ion beams with intensities less than 10^7 nuclei/second; (5) non-destructive beam diagnostics for stored ion beams such as at the RHIC and/or for 100 mA class electron beams; (6) devices/systems that measure the emittance of intense (>100kW) cw ion beams, such as those expected at a future rare isotope beam facility; (7)

beam halo monitor systems for ion beams and (8) instrumentation for electron cloud effect diagnostics and suppression..

Grant applications also are sought for "intelligent" software and hardware to facilitate the improved control and optimization of charged particle accelerators and associated components for nuclear physics research. Areas of interest include the development of (1) generic solutions to problems with respect to the initial choice of operation parameters and the optimization of selected beam parameters with automatic tuning; (2) systems for predicting insipient failure of accelerator components through the monitoring/cataloging/scanning of real-time or logged signals; and (3) devices that can perform direct 12-14 bit digitization of signals at 0.5-2 GHz and have bandwidths of 100+ kHz.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

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* Book description and ordering information available from Springer-Verlag New York, Inc. Website: http://www.springer-ny.com/aip/

47. 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, lower power usage, and low access latency to frequently used data. 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 also are 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, SRB, 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, storage buffers coupled to10 Gbps (or greater) networks, and end-to-end monitoring and diagnostics of WAN file transport; (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 relevant components of the Virtual Data Toolkit (VDT), supported and developed by OSG and Worldwide Large Hadron Collider (LHC) Computing Grid (WLCG) as the foundation of the grid middleware used by NP and other science communities. 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, process and distribute 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 and Cloud Computing— Grid deployments such as the Open Science Grid (OSG) in the U.S. and the Worldwide Large Hadron Collider (LHC) Computing Grid (WLCG) in Europe provide standardized infrastructures for scientific computing across large numbers of distributed facilities. To support these infrastructures, new computing paradigms have begun to emerge: (1) Grid Computing, sometimes called "computing on demand," which supports highly distributed and intensive scientific computing for nuclear physics (and other sciences); and Cloud Computing paradigm, which could offer an application-specific computing environment by allowing deployment of application-requested virtual machines. Accordingly, 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. 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 WLCG. Software solutions should enable rapid access to computing resources as they become available to users who do not have the necessary application software environment installed.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov)

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48. NUCLEAR PHYSICS ELECTRONICS DESIGN AND FABRICATION

The DOE Office of Nuclear Physics 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 48 (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 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. Active Pixel Sensors—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 sensors, 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.

Questions - contact Manouchehr Farkhondeh (manouchehr.farkhondeh@science.doe.gov).

e. 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).

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http://www.sciencedirect.com/science/publications/journal/physics

49. 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 the 12 GeV Upgrade of Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF), a future facility for rare isotope beams (FRIB), and other radioactive beam facilities being developed globally, the underground laboratory proposed by the National Science Foundation, DUSEL, the ongoing luminosity upgrade at RHIC, and a possible future electron-ion collider, EIC. 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. Grant applications are sought to develop advancements in the technology of 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 ($\sim 10^{20}$ 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).

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; (4) cost-effective production of n-type and p-type silicon drift chambers with active areas greater than 16 cm^2; (5) novel, low-noise cooling devices for efficiently operating these silicon drift chambers and other solid state detectors described in (2)-(4); and (6) techniques for substantial cost reduction of large-mass Ge detectors.

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.

In addition, grant applications are sought to develop devices designed to perform precision calibration of the detectors listed above. 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.

Finally, grant applications are also invited for innovative design of high-resolution particle separators needed for a spectrometer research program associated with a next generation rare isotope beam facility. Interested parties should contact Dr. J. A. Nolen, Jr. at Argonne National Laboratory (nolen@anl.gov).

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 ^{76}Ge, ^{82}Se, ^{130}Te, ^{136}Xe – and other materials that 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. Specialized Targets for Nuclear Physics Research—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; (6) thin (<few micro-g/cm^2), condensed-phase hydrogen targets that can be well localized (1mm in all directions), (7) very thin windows for gaseous detectors, to allow the measurement of low energy ions.

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.

Grant applications also 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)

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OFFICE OF ADVANCED SCIENTIFIC COMPUTING RESEARCH

50. SOFTWARE LIBRARIES AND APPLICATIONS MAINTENANCE AND SCALING TO PETASCALE

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 that are used 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 these libraries can be accessed effectively by the user community and that the value of the software contained in these libraries is maximized.

Limited computer resources at DOE facilities can be made available to successful Phase I applicants for proof of concept if properly justified in the proposal. Additional computer resources also can be made available during Phase II to fully develop proposed concepts. **Grant applications are sought only in the following subtopics.**

a. Technology to Support the Accessibility and Maintenance of Scientific Software Libraries—With the increased proliferation of software applications, there exists a need to ensure that an orderly and efficient mechanism exists for configuration control and distribution of software applications and libraries. Grant applications 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 scientific simulation of complex natural phenomena on a scale not possible just a few years ago. In order to take full advantage of petascale computing, existing mathematical libraries and tools must be scaled from existing terascale to petascale and beyond computer systems with tens of thousands of processors Therefore, grant applications are sought for the scaling of existing mathematical libraries, solvers, and tools, and development of new codes so that they will work efficiently with petascale computers at the DOE 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)

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51. 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. 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. 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.

Limited computer resources at DOE facilities can be made available to successful Phase I applicants for proof of concept if properly justified in the proposal. Additional computer resources also can be made available during Phase II to fully develop proposed concepts. **Grant applications are sought only in the following subtopics.**

a. 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.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

b. 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.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

c. 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 a 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.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

d. 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 visualization 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 is high or when the visualization work is collaborative in nature.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

e. 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)

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52. 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 (http://www/es/net). These end-to-end system-level technologies must be suitable for deployment and testing in the computing infrastructures of the DOE and other research and education networks. 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 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 data flows from cyber attacks must be carefully designed and deployed, so as to not hinder scientific discoveries or impede network traffic flows at data rates of OC12 and above. Grant applications are sought to develop intelligent and scalable cyber security systems that can operate at speeds up to 10 Gbps 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. Grant applications are encouraged to submit evidence of partnerships and letters of support from DOE laboratories, research and educational institutions, and other government agencies.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

c. High-Speed Data Transfer Tools and Services—Grant applications are sought to develop advanced network technologies that will enable the rapid distribution of data transfers over very long distances, needed to support the distribution of petabyte-scale data generated by scientific experiments and petascale simulation. Specific technologies of interest include, but are not limited to (1) Network Interface Cards (NICs) with embedded accelerators to enhance the host stacks performance; (2) integration of existing data transfers services such GridFTP, with advanced network provisioning technologies such GMPLS, to automate rapid data distribution; and (3) tools and services to enable the seamless integration of data transfer technologies with Storage Area Networks (SANS), for such wide area transport mechanisms as Infiniband, Fiber Channels, and SCSI systems. Approaches of interest must address end host issues with respect to the secure provision of terabit throughputs in a variety of scientific data transfer settings, including peer-to-peer and real-time data transfers.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

d. Federated Network Management Services and Technologies—Highly-secured community-based tools and services are needed to efficiently and effectively manage research and education networks that span several domains. Grant applications are sought to develop (1) secure and scalable network management tools and services such as performance prediction, fault location and diagnosis, dynamic circuit monitoring of heterogeneous multi-domain networks; (2) Web 2.0 services for community fault and performance best practice publishing; (3) AAA security technologies for securing federated network management infrastructures; (4) tools and services to integrate network management capabilities with network provisioning technologies; (5) technologies to diagnose and isolate faults in federated networks; and (6) discovery services.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

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53. 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.

Limited computer resources at DOE facilities can be made available to successful Phase I applicants for proof of concept if properly justified in the proposal. Additional computer resources also can be made available during Phase II to fully develop proposed concepts. **Grant applications are sought only in the following subtopics:**

a. Petascale System Hardware and 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 subsystems; (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. 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/applied mathematicians; (4) have clearly focused scientific goals; and (5) identify the specific tools, technology, or techniques that will be adapted and developed for commercialization

Questions - contact George Seweryniak (seweryni@ascr.doe.gov)

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54. SCALABLE MIDDLEWARE AND GRID TECHNOLOGIES

Advances in high performance network capabilities and collaboration technologies are making it easier for large geographically dispersed teams to collaborate effectively. This is especially important for research teams that use major computational resources, data resources, and experimental facilities supported by DOE. The importance of collaboratories is expected to increase in the future. However, significant research questions must be addressed if collaboratories are to achieve their potential, namely, by providing: (1) remote access to facilities that produce petabytes/year; (2) remote users an with an experience that approaches "being there;" (3) remote visualization of terabyte to petabyte data sets from computational simulation; and (4) effective remote access to advanced scientific computers. Research and software tool development are needed to support coordinated and dynamic resource sharing in areas such as resource discovery, resource access, authentication, authorization, accounting, etc. in the areas listed below. Any tools or services developed should be interoperable according to emerging standards from the Global Grid Forum. **Grant applications are sought only in the following subtopics:**

a. Scalable Middleware Technologies—Grant applications are sought to develop 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. Areas of interest include, but are not limited to, secure directory services, scalable authentication/authorization services, deployable LAN and WAN QoS services, data streaming management, multicast and efficient broadcast capabilities, automatic resource discovery protocols, remote data access services, and network-attached memory and storage systems.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

b. Scalable Grid Technologies—Grant applications are sought to develop scalable grid technologies to support the emerging distributed computing network that provides dependable, consistent, pervasive, scalable, and efficient access to various resources integrated into a distributed infrastructure that can be accessed wherever and whenever by DOE scientists. These resources include visualization systems, computer systems, data storage and archive systems, and scientific instruments. Areas of interest include, but are not limited to, collaborative visualization systems, collaborative problem solving services, application level fast data transfer toolkits, real-time analysis, group collaboration, co-scheduling distributed resources, grid accounting and billing mechanisms, data management tools, science portals, on-line instrumentation, and fast data transfer management services.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

c. Scientific Hosting Services and Tools - Grant applications are sought to develop scalable hosting services composed of light-weight Web 2.0 tools to open up a new modality for distributed scientific collaboration that complements and augments the effective use of middleware and grid technologies. Additional real-time and context-sensitive information (through annotation, syndication, messaging, tagging, chat, wikis, discussion forums, persistent identifiers, virtual agents, etc.) shows promise in providing greater transparency of conditions that impact decision-making and coordinated actions by distributed scientific teams. These capabilities would also accelerate integration and trouble-shooting of scientific workflows and usability of tools by "flagging" relevant information, in effect, using Web 2.0 tools as a light-weight communications and coordination scaffold.

Questions – contact George Seweryniak (seweryni@ascr.doe.gov)

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6. *SciDAC (Scientific Discovery through Advanced Computing)*, U.S. DOE Office of Science http://www.scidac.org

7. *Open Science Grid* http://www.opensciencegrid.org/

8. *Earth System Grid* http://www.earthsystemgrid.org/

OFFICE OF FUSION ENERGY SCIENCES

55. 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 Barry Sullivan (barry.sullivan@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 Barry Sullivan (barry.sullivan@science.doe.gov)

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

Grant applications are sought for:

(1) innovative and advanced superconducting materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs. Of specific interest are materials such as MgB_2 with properties that allow for operation near 20K, or YBCO conductors that are easily adaptable to bundling into high current cables carrying 30 - 60 kA. Desirable characteristics include higher critical current at 20 K and high field, higher copper fractions, lower losses, low sensitivity to strain degradation effects, high radiation resistance, and better cabling methods for tape conductors

(2) novel methods for joining coil sections for manufacture of demountable magnets that allow for highly reliable, remakeable joints that exhibit excellent structural integrity, low electrical resistance, low ac losses and high stability in high field and pulsed applications. These include conventional lap and butt joints, as well as very high current plate-to-plate joints, as in a tokamak Toroidal Field system

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

(4) radiation-resistant electrical insulators,e.g., wrapable inorganic insulators and low viscosity organic insulators that exhibit low gas generation under irradiation, less expensive resins and higher pot life. Insulation systems with high bond and higher strength and flexibility in shear.

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

d. Structural Materials and Coatings—

Grant applications 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. In addition, development of engineered tungsten/PFC materials to control or eliminate blistering associated with the interaction of tungsten with He and H isotopes from the plasma by providing high diffusivity paths to release He and H and decrease retention of these gases is of interest.

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

Grant applications also are sought to develop failure assessment and lifetime prediction methodologies of structural materials in the fusion environment, including physics-based methods to determine damage accumulation, residual life, and reliability of structural components under combinations of steady and cyclic loading, high-temperature, and neutron irradiation.

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 BarrySullivan (barry.sullivan@science.doe.gov)

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56. 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) high precision retroreflectors for CO_2 (10.6 micron) lasers that are compatible with service behind the ITER first wall for the ITER tangential interferometer/polarimeter system and the ITER divertor interferometer system; (2) fiber-optic-based laser endoscope for remote ablation of coated deposits on diagnostic mirrors; (3) motion-compensating miter bends in overmoded, corrugated microwave waveguide; (4) multi-band power combiner/divider for multiplexing several microwave waveguide bands into and out of overmoded corrugated waveguide; (5) broadband polarization separators in overmoded corrugated waveguide for the ITER low-field-side reflectometer system; and (6) microwave notch filter at the ITER electron cyclotron heating (ECH) frequency for the ITER low-field-side reflectometer system and the ITER electron cyclotron emission 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—Grant applications are sought to develop components related to the generation, transmission, and launching of high power electromagnetic waves in the frequency ranges of Ion Cyclotron Resonance Heating (ICRH, 50 to 300 MHz), Lower Hybrid Heating (LHH, 2 to 10 GHz), and Electron Cyclotron Resonance (or Electron Bernstein Wave) Heating (ECRH / EBW, 28 to 300 GHz). These improved components are sought for the microwave heating systems of the current large facilities in the United States (Alcator C-Mod, DIII-D and NSTX), facilities under construction (including ITER), and smaller machines exploring innovative and alternate concepts. Components of interests include power supplies, high power microwave sources or generators, fault protection devices, transmission line components, and antenna and launching systems. Specific examples of some of the components that are needed include tuning and matching systems, unidirectional couplers, circulators, mode convertors, windows, output couplers, loads, energy extraction systems from spent electron beams and particle accelerators, and diagnostics to evaluate the performance of these components. Of particular interest are components that can safely handle a range of frequencies and increased power levels.

For the ITER project, the United States will be supplying the transmission lines for both the ECRH system, at a frequency of 170 GHz, and for the ICRH system. For this project, grant applications are needed for advanced components that are capable of improving the efficiency and power handling capability of the transmission lines, in order to reduce losses and protect the system from overheating, arcing, damage or failure. Examples of components needed for the ECRH transmission line include low loss miter bends, polarizers, power samplers, windows, switches, and dielectric breaks. For the ITER transmission lines, improved techniques are needed for the mass production of components, in order to reduce cost. Lastly, advanced computer codes are needed to simulate the microwave, thermal, and mechanical components of the transmission lines.

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

c. Fusion Plasma Simulation and Data Analysis Tools—The accurate simulation of fusion plasmas is important for the design and evaluation of plasma discharge feedback and control systems and algorithms; the design, operation, and performance assessment of existing and proposed fusion experiments; and the interpretation of the experimental data obtained from these experiments. The simulation of fusion plasmas is very challenging because (1) the range of temporal and spatial scales involved is enormous, and (2) the nonlinear physical processes that govern the behavior of these plasmas are strongly coupled in the regimes of interest for fusion energy production. Although, in recent years, considerable progress has been made toward the understanding of these processes – including plasma transport driven by turbulence, macroscopic equilibrium and stability, and the behavior of the edge plasma – there remains a need to integrate the various plasma models to develop an integrated predictive simulation capability. In addition, efficient computational tools are needed to manage and analyze the enormous datasets resulting from large scale fusion simulations and experiments.

Grant applications are sought to develop computer algorithms and tools applicable to plasma simulations that incorporate an expanded number of plasma features and integrate multiple physics processes. Areas of interest include, but are not limited to, algorithms incorporating advanced mathematical techniques such as neural networks, sparse linear solvers, and adaptive meshes; multiscale algorithms; verification and validation tools, including efficient methods for facilitating comparison of simulation results with experimental data and synthetic diagnostics; data management, visualization, and analysis tools for local and remote multi-dimensional time-dependent datasets resulting from large scale simulations or experiments; techniques for coupling simulation codes, including coupling across different computer platforms and through high speed networks; methodologies for building highly configurable and modular scientific codes and flexible data interfaces; and remote collaboration tools that enhance the ability of geographically distributed groups of scientists to interact in real-time.

The simulation and data analysis tools should be developed using modern software techniques, should be able to take advantage of modern computer architectures, and should be based on high fidelity physics models.

Questions - contact John Mandrekas (john.mandrekas@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 more attractive and practical uses 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)

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57. HIGH ENERGY DENSITY LABORATORY PLASMA (HEDLP)

High energy density (HED) plasmas are plasmas with energy densities giving rise to pressures exceeding about 1 megabar (10^{11} Pa) and temperature exceeding 1 eV. The physics of plasmas at such high energy densities is an emerging field that cuts across many areas of science. The Office of Fusion Energy Sciences (OFES) sponsors research in this field motivated by potential applications to creating fusion reactions by inertial confinement. High risk, high payoff research are being undertaken seeking physics pathways to facilitate ignition and burn with attractive targets resulting in high gain x efficiency product for the fusion reactions. Emerging concepts include fast ignition, shock ignition, magneto-inertial fusion and heavy ion fusion. Novel approaches in these areas include ion-driven fast ignition, plasma jets forming imploding liner, magnetic flux compression, and compression of ion beams. This topic seeks proposals to supplement the on-going research activities in these areas. 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. 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. 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 on-going research in these areas. 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. Magneto-inertial fusion, and other innovative approaches to create high energy density plasmas — In magneto-inertial fusion, a magnetized target plasma is compressed to high densities and temperatures to achieve ignition and burn. Interest in this topic includes research in innovative approaches in magneto-inertial fusion and for creating HED plasmas. Of particular interest is the development and use of dense, high-Mach-number, high-velocity-plasma jets/beams to create HED plasmas. Grant applications are sought for computational, experimental, and component development in support of on-going research in these areas. 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)

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OFFICE OF DEFENSE NUCLEAR NONPROLIFERATION

58. REMOTE SENSING

The Remote Sensing Program has been a cornerstone in the national capability for the detection of proliferation facilities and activities for decades. The Remote Sensing Program consists of research projects that encompass a wide variety of potential capabilities to detect signatures associated with the development of weapons of mass destruction (WMD) with specific emphasis on nuclear weapons. The research areas in the Remote Sensing program include sensor development, image processing and digital signal processing technique for characterization of observed phenomena.

a. Small, High-density Electronics for High-rate Digitized Waveform Readout— Grant applications are sought to develop chip-level electronics for amplification and digital readout of signals from microchannel plates with cross-strip anodes consisting of ~100 strips, each read out individually. (See Siegmund et al, 2007 IEEE NSS conference record, page 2246 for information about the detector concept and the current electronics system.) The objectives are to (1) approach GHz frequencies for overall event rates, so that single-channel event rates could reach tens of MHz; and (2) provide low-noise (~100 electrons RMS) amplification of pulses with widths from tens of nanoseconds down to a few nanoseconds, producing output signals with short tails in closely separated pulses, in order to minimize baseline shifts. Additionally, for fast waveform digitization, a small, high-density (at least 8 channels on a single chip), 10-to-12 bit digitizer with GS/s timing resolution is desired, although it is currently beyond the state-of-the-art for chip-based digitizers.

Grant applications also are sought to develop high-speed analog samplers that use switched capacitor arrays to sample signals at GS/s rates, and then read out the digital information at lower rates. Such an analog sampler could be used as an intermediate stage between the amplifier and a digitizer operating at approximately 50 MS/s. The sampler's input must be well-matched to the amplifier and its output must be compatible with the digitizer.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

b. Long-Wave Infrared Transmitting Optical Fiber—To support remote sensing systems currently under development, grant applications are sought for a new class of infrared transparent optical fibers having low loss (< 3 dB/m) in the 8-12 µm range, low dn/dT, low NA, high optical power delivery capacity (~1W), operating temperature > 100 °C, and rugged mechanical properties. Approaches of interest should seek to incorporate: (1) novel infrared glass combinations; (2) novel fiber preform fabrication and fiber drawing techniques; (3) photonic band gap designs and sub-wavelength structures; (4) high performance antireflection coatings, based on either dielectric films or sub-wavelength structures; and (5) single-mode fiber development. Single-mode chalcogenide glass optical fibers are most desirable, but other optical materials and multi-mode designs will be considered.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

c. FTIR Detectors Optimized for the 300-to-1000 cm^{-1} Region—The 300-1000 cm^{-1} spectral region, commonly referred to as the *fingerprint* region, is rich in spectral signatures. In addition, blackbody emission at room temperature peaks in this region. Traditional infrared detectors that span the 300-1000 cm^{-1} region suffer from a number of idiosyncrasies that reduce their performance and operational ease. The workhorse of this spectral region has been the liquid-nitrogen-cooled, photoconductive mercury-cadmium-telluride (MCT) detector. Unfortunately, photoconductive MCT detectors generally suffer from significant non-linear response, making quantitative measurements cumbersome. In addition, MCT detectors optimized for longer wavelengths have poor response (low D-star). Commercially available alternatives consist of liquid-helium-cooled bolometers, which have superb D-stars; however, these detectors have slow response (KHz), which precludes them from several important applications. In addition, liquid helium is expensive and difficult to use. Therefore, grant applications are sought to develop FTIR detectors for the 300-to-1000 cm^{-1} spectral region with the following specifications: (1) liquid nitrogen cooling (preferred), to avoid liquid He; (2) D-star > $5x10^{10}$ cm $Hz^{1/2}$ W^{-1}; (3) flat responsivity across the spectral region; (4) linear response as a function of energy; and (5) detector response better than 1 MHz.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

d. Accurate Measurement and Calculation of Sky Temperature—Grant applications are sought to develop more accurate and generally applicable algorithms for calculating sky temperature from air temperature, humidity, and cloud cover. Approaches of interest should (1) include an improved version of a simple empirical or basic physics model; (2) include a more complete and computationally demanding algorithm that addresses elevation angle and azimuthal variations, partial cloud cover, aerosol effects, and extreme atmospheric conditions such as strong polar winter temperature inversions; and (3) specify the sky temperature in terms of the part of the thermal spectrum represented by the algorithm, i.e., mid-wave IR (3 – 5 microns), long-wave IR (8 – 12 microns), or some other waveband range. Algorithm validation must include an uncertainty analysis that propagates input errors through the computation to the final estimated sky temperature.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

e. Spectral Assisted Moving Vehicle Tracking—The automated tracking of moving vehicles uses techniques that rely on spatial-temporal characteristics coupled with moving object maps and tracking techniques. When these techniques fall short of their goals, additional characteristics that can uniquely identify a target vehicle must be considered. For example, the spectral observable of moving vehicles may be useful to improve the efficacy of tracking. Therefore, grant applications are sought to incorporate spectral-assisted techniques into the tracking of moving vehicles, ultimately in real-time.

Spectral observables of interest include both day/night longwave infrared (8-13 microns) and day-only visible/near-infrared/shortwave infrared (0.5 to 2.4 microns). Phase I should focus on understanding the phenomena associated with spectral observables of vehicles, in both bands, and on the development of algorithms that can distinguish one vehicle from another by their spectral/thermal characteristics. Algorithms should be tested using data collected on stationary vehicles from ground instruments.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

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59. ALTERNATIVE RADIOLOGICAL SOURCES

The mission of NNSA's Global Threat Reduction Initiative (GTRI) is to reduce and protect vulnerable nuclear and radiological materials located at civilian sites worldwide. The Nuclear and Radiological Material Protection subprogram supports the protection of at-risk WMD-usable nuclear and radiological materials worldwide from theft and sabotage until a more permanent threat reduction solution can be implemented. These efforts result in threat containment because WMD-usable materials are protected from theft and sabotage.

a. Alternative Radiological Sources—The Alternate Radiological Sources R&D Program is a new initiative that supports NNSA's GTRI efforts by focusing on the replacement of high intensity radioactive sources used in research and industry with alternative technologies and/or radioactive sources that reduce the threat of their use in Radiological Dispersal Devices (RDD) or Radiological Exposure Devices (RED). Stakeholders include manufacturers, distributors, industry associations, professional organizations, users, waste brokers, recyclers, disposal facilities, and federal and state governments. For this subtopic, grant applications are sought to develop new or alternative (preferably, non-radiological) sources to replace those currently being used in self contained blood and/or research irradiators. Proposed replacements or alternatives must provide equivalent (or improved) functionality and be less susceptible to malevolent use. Grant applications must address (1) the economic feasibility of the proposed alternative or replacement, (2) ease of maintenance (for both the equipment and the source), and (3) relative accessibility in and around the device.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

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60. SIMULATION AND SOFTWARE TOOLS FOR NONPROLIFERATION R&D

The Simulation, Algorithm and Modeling (SAM) Program develops and exploits models, simulations, advanced data processing concepts, and algorithms to enable the detection and assessment of nuclear proliferation activities. By investing in high-impact, long-term, and high-risk theory and information science and technology research, the SAM Program provides research and development support to the other programs within NNSA and advances the overall state of the art in this technical area. Science and technology projects within the SAM Program are aimed at extracting semantic meaning from data, in order to gain knowledge about nuclear proliferation activities. Areas of investment include the development of context-aware models of clearly defined proliferation event processes or features, simulation methods to assist the modeling efforts in replacing difficult-to-collect data, and ways to improve computational scaling of algorithms within SAM simulation and data mining efforts. SAM is also assessing the utility of social, political, and economic models to aid in the detection of potential nuclear proliferation activities.

a. Determination of Utility of Data Fusion— Multiple proposals to the SAM program propose a variety of data fusion approaches to the discovery of more specific signatures of proliferation activity. Proposals claim a level of utility to combining heterogeneous sensor data that is unobtainable from the uncoupled analysis of the multiple sources. Grant applications are sought to develop software for the efficient determination of the utility of data fusion between specific data sources using existing statistical analysis techniques. Approaches of interest should provide (1) a highly general package that can operate on generic data files or statistical data models, independent of the data source; and (2) a graphical representation of the parametric region of the utility of fusion and conditions under which maximum utility is achieved.

For more than four decades, the Space-based Nuclear Detonation Detection (SNDD) program and its predecessors have advanced nonproliferation and supported national defense. The SNDD program resides in NA-22, the Department of Energy (DOE)/National Nuclear Security Administration (NNSA) Office of Nonproliferation Research and Development, and carries out is missions through partnerships with the Department of Defense, DOE, and other government agencies. Fulfilling this specialized mission by providing space-qualified payloads and technical expertise for detailed data analysis distinguishes the SNDD program from other elements of NA-22. The program (1) conducts research and development to use new science and technology to address changing requirements, (2) infuses the results into the production of current instruments and algorithms without disrupting deployment schedules or budgets, and (3) supports users by ensuring the end-to-end performance of delivered systems and contributing to requirement redefinitions.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

b. Tools for Radiation Tolerant and/or Hardened Microelectronics Coding for Space Systems—Grant applications are sought to develop software toolkits to facilitate the conversion of standard Hardware Description Language (HDL) written in either Very-High-Speed Integrated Circuits Hardware Description Language (VHDL) or Verilog HDL to fault tolerant HDL for the implementation of space flight code in large format Field Programmable Gate Arrays (FPGAs). Approaches of interest should include, within the toolkit, novel method to validate the integrity of the software and error correction algorithms. Ultimately, an extensive and deep collaboration with laboratories of the Office of Nuclear Nonproliferation Research and Development (NA-22), as well as other US Government laboratories and partner entities, will be required to successfully implement the technology. Therefore, grant applications should demonstrate an ability to work with COTS-in-Space development efforts and to collaborate within an existing team of laboratory partners.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

c. Neutron Transport Interface—In current research programs to develop instruments for neutron detection, simplifying assumptions are frequently made in estimating the resolutions and efficiencies attainable. These assumptions tend to ignore scattering from materials around both the source and the detector, and they also ignore the attenuation and scattering that occur along the path between them.[1] Monte Carlo programs such as MCNP,[2] GEANT,[3] and DORT[4] are capable of realistically modeling such effects, 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. An interface that would enable simple geometries to be modeled by moderately knowledgeable users would benefit detector programs across a number of agencies (NA-22, DHS, DNDO, and DTRA). Therefore, grant applications are sought to develop user-friendly interfaces for 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.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

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Subtopic c. Neutron Transport Interface

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3. "GEANT4," http://geant4.web.cern.ch/geant4/ .

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5. "MORITZ Geometry Tool," White Rock Science, http://www.whiterockscience.com/moritz.html .

61. SEISMIC SIGNAL ANALYSIS

Seismic signal analysis is an important area within the Ground-based Nuclear Explosion Monitoring Research and Development (GNEM R&D) Program in the Office of Nuclear Detonation Detection (NDD). The mission of the GNEM R&D Program is to develop, demonstrate, and deliver advanced technologies and systems to operational monitoring agencies to fulfill US monitoring requirements and policies for detecting, locating, and identifying nuclear explosions (see Reference 1). Improved seismic signal analysis will help improve national capability for the Air Force Technical Applications Center (Reference 2) to monitor for nuclear explosions which are banned by several treaties and moratoria. Annual research progress of the GNEM R&D program is available in the Proceedings posted on-line (see Reference 3).

a. Tools for Digitization of Historic Seismograms—Originally, seismograms were recorded on paper or film of various sizes. Sometimes, critical information was transferred to microfilms. These data may be optically scanned for digital storage and review, but in this form they are not usable for further analysis. Commercial waveform digitization software exists but does not adequately address the problems encountered in these recordings. These problems include identifying and tracking multiple seismic traces in a single image, following traces that overlap adjacent traces, handling variations in the visibility of the trace, and correcting for distortion caused by the original recording mechanism (e.g., for a curvilinear pen recording). Grant applications are sought to improve and automate the recovery of digital seismogram traces from digital images of historic hardcopy records. Approaches of interest should (1) sample digital output traces at uniform sampling rates appropriate for each type of seismic instrument; and (2) assure that the amplitude resolution of the samples is adequate to capture a faithful replica of the original traces, presumably in 12-bit or 16-bit digital formats. 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),
- CSS (Center for Seismic Studies).

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

b. Seismic Instrument Response Recovery— Instrument response uncertainty is a pervasive difficulty in seismic data analysis. Often instrument calibration was not conducted or is not available. The recording gain is particularly troublesome because gain can, and often is, adjusted by station/network operators over time. Grant applications are sought to estimate, assess, and chronicle seismic instrument response from recorded seismic signals. Instrument response should comprise the complete recording system, including sensor transducer, analog electronics, and digital recording system, so that earth motion can be accurately calculated from the recorded digital signals. Also, the instrument response should be output in a commonly-used seismic format – preferably as poles, zeros, and gain – as a table of amplitude and phase at a range of frequencies, or, at a minimum, as an estimate of pass band and gain. Approaches of interest should (1) develop a method or methods to assess instrument response using recorded seismic data and (2) be capable of detecting a change in instrument response.

Questions – contact Frances Keel (frances.keel@hq.doe.gov)

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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 ELECTRICITY DELIVERY AND ENERGY RELIABILITY

62. ADVANCED TECHNOLOGIES FOR ELECTRICITY SYSTEMS

Although maintaining a high level of reliability for decades, the United States power grid is rapidly running up against its limitations. A changing supply mix, expanding power quality needs, and continuing demand growth are stressing an aging, congested electricity infrastructure, and thus challenging system reliability. The Nation's lights may remain on, but the risks and complexity of achieving this are growing every day. The challenge is to find a balance between (1) the upgrades necessary to achieve a stronger, more adaptable transmission and distribution system in the future and (2) other actions that are urgently needed in the near term, such as energy efficiency, demand response, and adoption of commercially-ready smart grid technologies. **Grant applications are sought only in the following subtopics**.

a. Electricity System Visualization—There is a vast amount of information on the electricity system that could be collected and utilized. However, such data would be of little value to a system operator in its as-received condition. To be effective, appropriate tools must reduce and simplify the data into the format, time frame, and technical categories most important to the system operator and/or transmission planner. These tools must also cue the operator to potential system problems. This is the role of advanced visualization tools. Therefore, grant applications are sought to improve the visualization of electricity information to system operators and/or transmission planners. Approaches of interest should (1) leverage recent advances in human factors engineering techniques, and in computer hardware and software technology, in order to move beyond the simple tabular displays and one-line diagrams in common use today; and (2) be practical and implementable in an operational enviroment. Priority will be given to approaches that can achieve visually appealing and effective displays for advanced system monitoring and control room designs, reflect a strong understanding of power system planning and operational needs, and utilize practical data methodologies.

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

b. Smart Grid Technologies for Renewables Integration—Grant applications are sought to develop software tools and control methods to support system operators in the day-to-day operation of a power system in which there is a high penetration of renewables. Of particular interest is the development of intelligent agents and/or decision support tools for utility and system operators. Approaches of interest should stress the interaction between the control system and the operator:

- Advanced control methods can do much to stabilize the grid, but system operators will still be responsible for monitoring these controls and making decisions that are beyond prescribed “permission sets” - the set of circumstances or conditions where technologies are given permission to act without first “checking” with the operator. When actions are required of the operator, the control system should present options to the operator in a way that maximizes the probability of success (i.e., alerting operators to existing, emerging, and predicted problems).

- Risk-based approaches to decision-making are preferred - especially compared to approaches in which actions are based on the single most severe credible contingency. The risk-based approach recognizes that credible contingencies have different probabilities of occurrence. By understanding the consequences of each contingency and its probability of occurrence, decision support systems can quantify the relative risk and severity. These relative risks should be presented to the operator to assist with decision-making.

Areas of research interest include, but are not limited to, (1) the integration of renewable resource prediction software with utility operational and planning models; (2) real-time dynamic simulators for training; and (3) system performance dashboards.

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

References

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63. ADVANCED ENERGY STORAGE

The projected doubling of world energy consumption within the next 50 years, coupled with the growing concerns over climate change, have brought increasing awareness of the need for efficient, clean energy sources. However, renewable energy sources such as solar and wind are intermittent. Substantial penetration of such intermittent generation will place considerable stress on the U.S. electricity grid. Large scale, efficient, electrical energy storage (EES) systems can compensate for intermittent generation and ensure that electricity is reliably available 24 hours a day. 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 some renewable energy sources. Among available options, flowing-electrolyte batteries, or "flow batteries" have shown considerable progress. However, improvements in cost, energy density, and manufacturability are needed to make flow batteries economically competitive. **Grant applications are sought only in the following topic**.

Utility-Scale Flow Batteries—Flow batteries are beginning to become of interest to utilities in a number of applications requiring buffers for variability in load and supply of electricity. Vanadium redox and Zinc-Bromine flow batteries are currently available while other battery chemistries are being explored. Flow batteries provide an opportunity to separate energy and power needs, offer flexibility in design, and can be sized to meet utility requirements for integrating renewable energy. However, substantial improvements are needed before such batteries can reach widespread deployment. Grant applications are sought to improve the performance and manufacturability of advanced utility-scale flow batteries. Approaches of interest include new electrochemical couples or improvements in current couples, electrode and membrane development, and technology to achieve greater energy density and lower cost, in order to meet the large scale needs for these energy storage systems.

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

References

1. EPRI-DOE Handbook of Energy Storage Transmission and Distribution Applications, Chapters 9, 10 & 11. EPRI Report 1001834
   http://www.science.doe.gov/sbir/solicitations/FY%202006/15.FE3.htm

2. Energy Storage for Grid Connected Wind Generation Applications, EPRI-DOE Handbook Supplement. EPRI Report 1008703
   http://www.science.doe.gov/sbir/solicitations/FY%202006/15.FE3.htm

OFFICE OF SCIENCE

64. 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 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 subtopics.**

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. Specific areas of interest include advances in federated searching of the deep web or other low-cost means for virtually integrating dispersed resources. Proposed approaches must emphasize the development of user-friendly tools and deployable concepts across the broad spectrum of worldwide science. Intended audiences include science and engineering researchers, science-attentive citizens, and/or students at various levels.

b. Data Integrity Analysis, Anomaly Detection, and Correction Tools—Data sets are increasing at an exponential rate and the ability to detect, correlate, and enhance data significance is becoming increasingly critical. Research organizations frequently must correlate numerous independent and sometimes disparate legacy data sets in order to facilitate research. Grant applications are sought to develop scalable concepts and technologies, applicable to very large data sets, for the purpose of analyzing, detecting, and correcting various data anomalies. Proposed technologies should demonstrate the capability to manipulate very large data sets utilizing efficient processing algorithms to enhance speed and accuracy. Specific areas of interest include data duplication detection, data consistency, and data manipulation/correction algorithms

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)

OFFICE OF ENVIRONMENTAL MANAGEMENT

65. IMPROVED CHARATERIZATION OF WASTE IN TANKS AND ACILLARY PIPING

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

The heterogeneous materials, both in the tanks themselves and in their ancillary piping, need to be characterized in order to better understand (1) the dissolution or precipitation that can happen during retrieval or processing; (2) the chemical changes that occur in slurries and solutions in real time; (3) the chemical speciation and bonding preferences of contaminates of interest; and (4) the chemical and physical properties of wastes (such as heels and sludges) remaining in the tanks after retrieval. The characterization of tank wastes poses many challenges due to the large volume of the tanks, the physical and chemical complexity and heterogeneity, and the radioactivity or toxicity. Improved characterization of the physical, chemical, and radiological properties of the waste is needed to reduce technical risks and uncertainty associated with retrieval, treatment, and disposal; to improve safety; and to reduce secondary waste generated by existing techniques.

Grant applications are sought only in the following subtopics.

a. Technologies for Improved *in situ* Characterization—Current waste characterization technologies require either in-tank probes or sample collection followed by laboratory analysis. Grant applications are sought for developing non-invasive tank characterization techniques that avoid the cost, personnel radiation exposure, and secondary waste generated by existing technologies. Areas of interest include the characterization physical parameters (e.g., density, particle size, viscosity, fraction of solids), chemical parameters (i.e., chemical speciation and ionic valence), and radiological composition (i.e., alpha, beta, gamma at all energy levels) using advancement in the latest instrumentations.

Questions - contact Justine Alchowiak (justine.alchowiak@em.doe.gov

b. Technologies for Characterization of Tanks and Ancillary Piping after Bulk Retrieval—Following bulk or specialized retrieval operations for the waste in tanks, some residual material will remain. The characterization of this residual waste, both in the tanks and in their ancillary piping, presents problems from both volume and chemical/radiological standpoints. In particular, the size and geometry of the tanks, limited points of access, and obstructions (cooling coils and other tank components) make accurate residual waste measurement difficult. Grant applications are sought for improved remote sampling and characterization tools to assess the quantity and composition (physical, chemical and radiological) of residual tank waste and waste remaining in associated ancillary piping.

Questions - contact Justine Alchowiak (justine.alchowiak@em.doe.gov

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1. U.S. Department of Energy, Office of Environmental Management Website. (http://www.em.doe.gov/)

2. U.S. Department of Energy, Office of Environmental Management, *Engineering and Technology Roadmap*, March 2008. (http://www.em.doe.gov/Pages/EngTech.aspx)

3. U.S. Department of Energy, Office of Environmental Management, *WASTE PROCESSING MULTI-YEAR PROGRAM PLAN FY 2008-2012.* (http://www.em.doe.gov/Pages/TankWasteProcessing.aspx_)

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5. U.S. Department f Energy, Office of River Protection website. (http://www.hanford.gov/orp/)

6. U.S. Department of Energy, Idaho Operations Office website. http://www.id.doe.gov/

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8. National Academy of Sciences, National Research Council. 2005. Improving the Characterization and Treatment of Radiological Wastes. (http://www.nap.edu/catalog.php?record_id=11200_)

9. P. D. d'Entremont, et al., "Characterization of Tank 17 Residual Waste," WSRC-TR-97-0066.
(Full text available at: http://sti.srs.gov/fulltext/tr2002052r1/tr2002052r1.pdf)

OFFICE OF NUCLEAR ENERGY, SCIENCE AND TECHNOLOGY

66. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Nuclear power provides over 20 percent of the U.S. electricity supply without harmful greenhouse gases or air pollutants, including those that may cause adverse global climate changes. New methods and technologies are needed to address key issues that affect the future deployment of nuclear energy and to preserve the U.S. leadership in nuclear technology and engineering, while enhancing resistance to nuclear proliferation. This topic addresses several of these key technology areas: improvements in nuclear reactor technology for existing light water reactors and evolutionary Gas Cooled Reactor designs, advanced instrumentation and control (I&C) for very high temperature reactor applications, advanced I&C for use in high radiation environments for the Next Generation Nuclear Plant gas cooled reactor designs, and advanced technologies for the fabrication, characterization and non-destructive testing of high quality nuclear reactor fuel for Generation IV reactor designs. Of particular interest are grant applications that propose the use of the Idaho National Laboratory's Advanced Test Reactor National Scientific User Facility for Phase I and/or Phase II. 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 9.

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 performance of the nuclear power plant and its systems, along with component instrumentation and control, by developing and improving the reliability of advanced instrumentation, thermocouples, sensors, and controls, and by increasing the accuracy of measuring of key reactor and plant parameters [6]; (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 gas cooled reactor (Generation IV) designs that can withstand temperatures in excess of 1400° C; and (4) for advanced instrumentation, sensors, and controls for the very high irradiation environments (> 10^{14} n/cm^{2}sec neutron flux levels) that will be encountered in advanced Generation IV high temperature gas reactor designs and sodium fast reactors [7, 8]. Grant applications that propose to use the Idaho National Laboratory (INL) Advanced Test Reactor (ATR) National Scientific User Facility [9] for demonstrating the performance of the instrumentation, sensors, or thermocouples are particularly sought and will need to prove technical feasibility prior to their insertion into the ATR for irradiation testing.

Grant applications that address the following areas are NOT of interest and will be declined: nuclear power plant security, homeland defense or security, or reactor building/containment enhancements; radiation health physics dosimeters (e.g., neutron or gamma detectors), and radiation 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 Technologies for the Fabrication, Characterization of Nuclear Reactor Fuel for Generation IV Reactor Designs -- Improvements and advances are needed for the fabrication, characterization and non-destructive examination of nuclear reactor fuel with technologies that could: (1) develop advanced automated, continuous vs. batch mode process fabrication, characterization, and non-destructive testing TRISO fuel for Advanced Gas-Cooled Reactors/NGNP applications [10, 11]; (2) enhance remote handling operations for using recycled spent nuclear fuel to produce new fuel pellets and rods for burning plutonium and minor actinides for Advanced Fuel Cycle Initiative (AFCI) and/or Global Nuclear Energy Partnership (GNEP) applications [7, 8]; and (3) automated AFCI/GNEP [7,8] fuel fabrication production methods, that can be used within hot cells or sealed glove boxes. Grant applications may use non-fueled surrogate materials to simulate uranium, plutonium, and minor actinide bearing fuel pellets or TRSIO particles for demonstration. Actual nuclear fuel fabrication and handling applications may propose to use the INL ATR National Scientific User Facility [9], and its hot cells and fuel fabrication laboratories, or the Oak Ridge National Laboratory Advanced Gas Reactor TRISO fuels laboratory facilities to demonstrate the techniques and equipment developed. Actual nuclear fuel specimens may be considered for ATR and ORNL High Flux Irradiation Reactor (HFIR) will need to prove technical feasibility prior to their insertion into the ATR or HFIR for irradiation testing.

Grant applications that address the following areas are NOT of interest and will be declined: Spent fuel separations technologies that are currently classified or may pose potential nuclear proliferation risks if commercialized; chemical or physical separation processes outside or beyond the UREX+ processes used in the GNEP program [7, 8] and applications that seek to develop new glove boxes or sealed enclosure designs.

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)

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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)

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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)

9. Idaho National Laboratory Advanced Test Reactor National Scientific User Facility. (URL: http://nuclear.inl.gov/atr/)

10. Idaho National Laboratory, "Technical Program Plan for the Advanced Gas Reactor Fuel Development and Qualification Program," Rev. 1, INL/EXT-05-00465, August 2005.

11. Idaho National Laboratory, "Technical Program Plan for the Next Generation Nuclear Plant/Advanced Gas Reactor Fuel Development and Qualification Program," Rev. 2, INL/EXT-05-00465, July 2008.