U.S. Department of Energy

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

FY 2010
Technical Topic Descriptions

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The funding opportunity associated with these topics is closed.

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1. HYDROGEN, FUEL CELLS, AND INFRASTRUCTURE TECHNOLOGIES PROGRAM

By enabling the widespread commercialization and near-term use of fuel cell technologies for stationary, portable, and transportation applications, the DOE's Hydrogen, Fuel Cells and Infrastructure Technologies (HFCIT) Program, within the Office of Energy Efficiency and Renewable Energy (EERE), works to reduce petroleum use, greenhouse gas (GHG) emissions, and air pollutants, as well as contribute to a more diverse energy supply and efficient use of domestic energy. Consistent with the President's objectives, HFCIT will develop multiple fuel cell technologies (including solid-oxide, alkaline, and polymer electrolyte membrane fuel cells) for multiple fuel sources (including diesel, natural gas, bio-derived renewable fuels such as methanol, and fuels derived from other renewable resources). Applications include distributed generation, backup power, auxiliary power units (APUs), portable power systems, material handling equipment, specialty vehicles, and transportation. Distributed generation and backup power systems supported by this activity may be grid-tied or grid-independent, utilize waste heat, operate directly with hydrogen or natural gas, or use reformers to operate with natural gas, bio-derived fuels or coal-derived fuels. **Grant applications are sought only in the following subtopics:**

a. Energy Storage for Intermittent Renewable Resources—Both wind energy and solar photovoltaics have emerged as focus areas for renewable energy research and development. Unfortunately, the variability of both wind and solar energy resources creates barriers to widespread acceptance of these technologies. To enable their greater use, an effective energy storage solution is needed to enable consistent power generation throughout the day. Water electrolysis can provide one method of energy storage. Excess solar or wind energy could be used to power the electrolysis generators to separate the water molecules into hydrogen and oxygen. The hydrogen then could be collected and stored. When electrical demand rises, the hydrogen could be used as the fuel in a fuel cell to produce electricity, which reduces the variability of these two clean energy sources.

Grant applications are sought to develop low-cost water electrolysis systems, with electricity supplied from solar photovoltaics (PV) or wind energy, that can achieve the HFCIT Program's efficiency and cost targets. The electrolyzer system efficiency target is 69% with a minimum hydrogen output pressure of 300 psi, including all auxiliaries other than compression. To further improve efficiency and lower capital costs, the electrolysis unit should be amenable to integration with other system components, such as power conditioning and storage. Applications should focus on improving the electrolyzer system efficiency and reducing manufacturing and balance of plant costs.

Phase I should include (1) proof-of-concept testing to demonstrate that the new materials, catalysts, and manufacturing have the potential to achieve the Program's 2012 targets; and (2) a technoeconomic analysis using the H2A Production spreadsheet tool. The analysis is to be conducted for a hydrogen production capacity of 50,000 kg of H_2 per day, using standard assumptions, and no by-product sales benefit.

Phase II should (1) include the fabrication of an electrolyzer system that produces 99.99% pure hydrogen at 300 psi, operates for at least 1000 hours, and maintains >69% efficiency from the beginning through the end of the operations testing; (2) address the requirements for operation and maintenance, along with any technology advancements required to scale the system to 50,000 kg/day H_2 production; (3) conduct an updated H2A analysis that accounts for system operating experience changes; and (4) conduct a separate analysis that estimates greenhouse gas and petroleum reductions that will occur with the successful implementation of the proposed technology.

Questions – contact Rick Farmer, 202-586-1623, Richard.Farmer@ee.doe.gov

b. Fuel Cell Balance-of-Plant—The HFCIT Program supports R&D efforts aimed at accelerating the deployment of fuel cell technology by reducing the high cost of fuel cell materials, lowering manufacturing costs, and extending fuel cell operating lifetimes. Several years ago, the cost of a fuel cell stack was much higher than the cost of the balance-of-plant (BOP); thus R&D funding focused on reducing the stack cost. Those R&D efforts succeeded in reducing the cost of fuel cell stacks to the point at which their projected high-volume cost is nearly equal to the cost of the rest of the fuel cell system.

Now, attention is being focused on BOP components. During fuel cell operation, BOP components are often the first to fail; system shutdowns caused by non-stack components reportedly accounting for 85-90% of system failures. More than 68% of all labor hours spent repairing fuel cells are devoted to repairing BOP components. Thus, grant applications are sought for R&D of BOP components, to reduce failure rates, lower costs, and reduce parasitic losses dramatically. BOP components of interest include, but are not restricted to, seals, motors, sensors, water vapor transport exchangers, heat exchangers, valves, pressure transducers, flow meters, pumps, and blowers. Applicants must show that their concepts will lead to components that will cost an appropriate fraction of the total cost target of BOP. (For example, a pump for transportation fuel cell applications should have a projected cost of an appropriate fraction of the 2015 target of $15/kW, assuming a production rate of 500,000 units/yr.) Also, as with the rest of the fuel cell system, BOP components must possess the required durability for the targeted application under appropriate operating conditions and regimes. In particular, components must last more than 5,000 hours under cycling conditions for transportation applications and more than 40,000 hours for stationary applications. The cost targets are $30/kW and $750/kW for transportation and stationary applications, respectively. Grant applications for transportation-related fuel cell systems must demonstrate a capability for successful operation under severe conditions, including power transients, high temperatures, sub-freezing temperatures, and low relative humidity.

Phase I applications should identify, develop, and characterize promising BOP component concepts for PEM fuel cells and small-scale solid oxide fuel cells (e.g., < 10 kW). Phase II should include the development, design, fabrication, and testing of the BOP components. The Phase II deliverables will include the proof-of-concept components along with a demonstration that the components can be integrated into fuel cell systems that meet the DOE cost and durability targets as defined above.

Questions – contact Nancy Garland, 202-586-5673, nancy.garland@ee.doe.gov.

c. Advanced Hydrogen Storage for Early Market Applications—The DOE's HFCIT Program previously developed performance and cost targets for on-board hydrogen storage for light-duty vehicles. However, many anticipated early market applications for hydrogen storage have performance and costs requirements that differ from those for light-duty vehicles. The early market applications of interest include materials handling equipment (e.g., lift trucks), stationary/back-up power, and portable power, specifically in the power range from 0.5 to 5 kW_{net}. Grant applications are sought to identify and develop the hydrogen storage performance and cost requirements for these early market applications and assess potential hydrogen storage technologies to meet them. Performance and cost requirements may include but are not be limited to: energy storage capacity (i.e. total amount of hydrogen stored), energy density (kg H_2/liter system), specific energy (kg H_2/kg system), operating temperatures, operating pressures, hydrogen delivery rates, refill times, cycle-life, transient response time, and cost. Grant applications would be strengthened by (1) including a market assessment that identifies competing technologies, the advantages and disadvantages of the proposed storage technology, (2) an analysis of the overall efficiency, greenhouse gas reductions, and petroleum use reductions that would result from the commercialization of the technology, and (3) identifying potential technology integrators of the hydrogen storage technology and including commitments from them to participate in the effort.

The Phase I project would be expected to (1) perform an in-depth analysis of the performance and cost requirements for hydrogen storage for a specific early market application (such as for class I fuel cell lift trucks or for back-up power for telecommunication towers), (2) identify a potential hydrogen storage technology to meet these requirements, (3) provide an assessment of the current state-of-the-art of the proposed hydrogen storage technology, along with a technical gap analysis. No material or hardware development should be proposed as part of the Phase I effort.

Phase II should focus on developing the proposed hydrogen storage technology to meet the performance and cost requirements for the application and on addressing the technical gaps identified in Phase I. Phase II may include material and hardware development and demonstrations of sub-scale systems, as appropriate. The Phase II effort should include a more thorough market analysis that includes the potential market size for successful technologies.

Questions – contact Ned T. Stetson, 202-586-9995, Ned.Stetson@ee.doe.gov.

d. Low-Cost Dispensing for Material Handling and Specialty Vehicles—Inexpensive refueling is critical to the widespread commercialization of materials handling and specialty vehicles (warehouse forklifts, airport tugs, fleet applications). Currently, depending on scale, near-term applications rely on onsite hydrogen generation or liquid hydrogen delivered. Grant applications are sought to develop low-cost refueling options for materials handling and specialty vehicles. Approaches of interest include energy-efficient and reliable compressors, and low-cost bulk hydrogen storage.

Before hardware is built, information must be provided about the cost trade offs related to dispensing. For example, information is needed regarding (1) the costs associated with the difference between refueling hydrogen at 0.5 kilogram per minute vs 2 kilograms per minute, and (2) the economics related to the number of forklifts that might be refueled in succession. Therefore, Phase I should focus on creating plans for a low-cost refueling station. The Phase I project should include a detailed technical analysis comparing today's refueling options against proposed improvements, along with an economic analysis that uses standard financial metrics and includes all relevant capital and O&M costs. The cost comparisons should address all aspects of the station, including, but are not limited to, compression, increased reliability, and energy efficiency. The plan should be sufficiently comprehensive that building could begin within several months after station site selection. Phase I also should provide an analysis of overall energy efficiency, petroleum use, and greenhouse gas emissions, from the point of fuel production, through dispensing, to the point of use.

Phase II would focus on site selection, proposed budget, actual station design, construction, and commissioning, resulting in a final report comparing forecasted and actual costs.

Questions – contact Monterey Gardiner, 202-586-1758, Monterey.Gardiner@ee.doe.gov.

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2. ADVANCED SOLAR TECHNOLOGIES

Solar energy is our largest energy resource and can provide clean, sustainable energy supplies, including electricity, fuels, and thermal energy. The President's economic recovery package emphasized solar energy, among others, as a key element in combating global climate change. However, the cost-effective capture of the enormous solar resource is problematic. This topic seeks to develop novel, commercially feasible, solar systems and production techniques.

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

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

Grant applications are sought in the following subtopics:

a. Manufacturing Tools for Reliability Testing—Grant applications are sought for the development of tools that can be used to conduct reliability testing in PV module manufacturing environments. For example, tools such as light soaking equipment are used to prepare modules or components for accelerated lifetime testing, which is frequently conducted in-house at the module manufacturing facility or by service companies before sending for official third party certification. New tools are needed for the testing of components (e.g., modules, inverters) or subcomponents (e.g., cells, microinverters, individual layers of a module), and should combine high performance, low cost, and a small floor footprint.

Questions – contact: Alec Bulawka (Alec.Bulawka@ee.doe.gov)
James Kern (James.Kern@ee.doe.gov

b. Module and System Manufacturing Metrology and Process Control—The rapid scale-up of the manufacturing of photovoltaics, particularly for new thin-film technologies, is challenging the possibility of using conventional technologies to make real-time non-destructive measurements of material characteristics in high-volume, high-production-rate environments and then using this information to implement real-time process control of the manufacturing process. Therefore, grant applications are sought for the development of novel, advanced, real-time non-destructive materials characterization tools for use in high-volume manufacturing lines for photovoltaic systems.

Questions – contact: Alec Bulawka (Alec.Bulawka@ee.doe.gov)
James Kern (James.Kern@ee.doe.gov

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

Questions – contact: Alec Bulawka (Alec.Bulawka@ee.doe.gov)
James Kern (James.Kern@ee.doe.gov

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3. ADVANCED THERMOELECTRIC TECHNOLOGIES

The Department of Energy is seeking the development of advanced thermoelectric technologies for (1) cooling applications (air conditioning, refrigeration, etc.) in buildings, industry, and vehicles that are more energy efficient than today's technologies while being cost-competitive with conventional systems; and (2) waste heat recovery in buildings, industry, and vehicle applications to generate electricity efficiently and cost-competitively. The focus of these approaches should be on thermoelectric devices and associated materials considerations, and on their integration into systems.

Grant applications submitted in response to this topic should include the following: (1) a review of the state-of-the-art of the technology (with citations to the relevant archival literature) and an identification of the application(s) being targeted (e.g., automotive, buildings, etc.); (2) a detailed evaluation showing how the proposed concept advances the state-of-the-art (e.g., in terms of energy efficiency, reduced lifecycle costs, reliability, market share, etc.) and addresses a large potential market; (3) an outline of the proposed technology development process, pathway to commercialization, and potential public benefits that would accrue; and (4) a discussion of the ease of implementation of the new technology and its potential for high reliability.

Phase I proposals should include (1) a preliminary design, (2) a characterization of laboratory-scale devices using the best measurements available, including a description of the measurement methods, and (3) a road map showing major milestones that would lead to a system that would be built and tested 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. Cooling in Buildings, Industry, and Vehicles—Cooling applications (air conditioning, refrigeration, etc.) in buildings, industry, and vehicles account for approximately 10 quads of U.S. primary energy consumption. Air conditioning is a major contributor to electric utility peak loads, which incur high generation costs (as they are generally produced by inefficient turbines) and are a major factor in poor grid reliability. Similarly, in the transportation sector, air conditioning accounts for roughly one-fifth of the power required by a mid-size sedan traveling at 60 mph on a hot day. This large load constrains the design of hybrid vehicles and will constrain the range of plug-in hybrids.

Another problem of today's cooling technology, which is based on the mechanical vapor compression cycle (VCC), is the greenhouse warming impact of the hydrofluorocarbon (HFC) refrigerant gases that are used. A recent study projected that in 2050, if CO_2 is stabilized at 450 ppm, HFCs would increase greenhouse gas forcing by 28-45 percent (Velders et al. 2009).

These factors necessitate a search for new approaches to increase the energy efficiency of cooling technologies and to avoid the use of refrigerants that have a net greenhouse warming impact. A recent SBIR solicitation (http://www.science.doe.gov/sbir/solicitations/FY%202009/ARRA_Topics.pdf) focused on (1) solid-state materials and devices that were not thermoelectric-based, (2) advanced working fluids and mechanical vapor compression systems, and (3) advanced absorption cycles. The present solicitation focuses solely on thermoelectric devices and systems. Thermoelectric systems, among others, also have the potential for localized cooling, if desired, rather than cooling the entire space in the building or vehicle to the desired temperature. This would reduce energy requirements. Yet they could still have the versatility to provide climate control of the entire interior if desired.

Much attention has been focused on thermoelectric modules to realize this potential, with existing work emphasizing improved efficiency through materials development. Equally important are the physical packages in which the thermoelectric materials are integrated and the associated energy management challenges that arise, such as the importance of thermal interfaces with low contact resistance, provisions to address thermal expansion mismatch issues, systems-level package integration, and the associated metrology to characterize performance.

Grant applications are sought to develop: (1) new thermoelectric materials for cooling that have a high figure of merit (ZT) and the potential for large-scale, low-cost production, at costs competitive with conventional technologies considering the full system over its lifetime; (2) modules to house thermoelectric materials that mitigate thermal expansion issues that can cause failure; and (3) thermoelectric systems that address all of the thermal interface, materials compatibility, and thermal management issues of the integrated system. Regarding materials development, the potential for large-scale manufacturing and at low cost is critical. Proposals that address all three of the above subjects are preferred. Collaborations with an OEM (Original Equipment Manufacturer) are encouraged.

Questions - contact Dr. Sam Baldwin, 202-5860927, Sam.Baldwin@ee.doe.gov

b. Advanced Waste Heat Recovery—Industry and vehicles, as well as buildings, discharge large quantities of waste heat – typically, well over half of the input energy. Larger scale systems, such as bottoming cycles, are available and have been widely used to recapture waste heat for electricity generation in the industry and power sectors. Unfortunately, few options are available at smaller scales, not only for use in vehicles but also for some commercial and industrial applications. The recovery of some of this waste heat, via thermoelectric technology, represents an enormous untapped opportunity. However, the operating temperatures for waste heat recovery are much higher than for cooling applications; therefore, the development of different thermoelectric and module materials, as well as different thermal management strategies, will be required.

Grant applications are sought to develop: (1) new thermoelectric materials for waste heat recovery and electricity generation that have a high figure of merit (ZT) and the potential for large-scale production, at costs competitive with conventional technologies considering the full system over its lifetime; (2) modules to house thermoelectric materials that mitigate thermal expansion issues that can cause failure; and (3) thermoelectric systems that address all of the thermal interface, materials compatibility, and thermal management issues of the integrated system. Proposals that address all three of the above subjects are preferred. Collaborations with an OEM (Original Equipment Manufacturer) are encouraged.

Questions - contact Dr. Sam Baldwin, 202-5860927, Sam.Baldwin@ee.doe.gov

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4. GEOTHERMAL ENERGY TECHNOLOGY DEVELOPMENT

The DOE's Geothermal Technologies Program aims to make geothermal energy a major source of clean, renewable, domestic electricity in the U.S. through carefully targeted technology research, development, demonstration, and deployment activities. Geothermal energy technologies include the generation of electricity and thermal energy using geothermal energy resources. Projects typically involve exploring for a subsurface resource, drilling wells into naturally-heated subterranean aquifers, and then circulating fluids to extract heat for energy production. The energy production process occurs either by expanding a hot fluid through a turboexpander that drives an electric motor or via direct use. Currently, only a fraction of U.S. geothermal resources are utilized to produce power. In 2008, approximately 3,000 MW of geothermal electricity was generated in the U.S. 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 cannot be produced by conventional means (i.e., without enhancement of their natural permeability or fluid content). A 2008 resource assessment by the United States Geological Survey (USGS) estimated that the western U.S. alone could produce up to 39,000 MW from identified and undiscovered hydrothermal resources and a further 518,000 MW from Enhanced Geothermal Systems (EGS), in which low permeability rock is fractured to enable fluid flow to extract thermal energy.

This topic is focused on the development and innovation required to achieve technical and commercial feasibility of EGS. Because of the complexity of these systems, grant applications are expected to focus on a component or supporting technology of EGS development that would enable improvements to the overall system. The unique function and innovation of the targeted subsystem or supporting technology must be clearly described and its function in relationship to the greater EGS system must be expressed clearly. Approaches can be targeted at any of the multi-step project stages for technology development: from design concept, through scale model development (if applicable), to laboratory testing, field testing, and commercial scale demonstrations.

Grant applications should (1) thoroughly describe the proposed subsystem or component and how it relates to EGS development and the Geothermal Technologies Program Multi-Year Research, Development and Demonstration (MYRD&D) Plan, (2) present a sound technical approach to accomplish the proposed R&D objectives through a well developed project plan, (3) demonstrate the expected feasibility of the proposed approach through credible engineering calculations and existing quantitative data, (4) provide evidence that the applicant and other team members are capable of comprehensively addressing all aspects of the proposed project, and (5) provide letter(s) of commitment to demonstrate the level of participation by project participants.

The Geothermal Technologies Program also seeks to promote the development of technologies to improve ground source heat pumps, also known as geothermal heat pumps (GHPs). Geothermal heat pumps use the relatively constant temperature of Earth's subsurface to heat homes and buildings in the winter and cool them in the summer by circulating fluid through an underground heat exchanging loop. GHPs provide a net electricity and energy savings by using the earth as a heat sink in hot weather and a heat source in cold weather. Improved component technology and innovative designs will improve the performance of GHPs, resulting in a higher level of efficiency reached by the GHP unit itself, as well as achieving even higher energy savings through the use of GHPs for heating and cooling vs. conventional systems. Additionally, innovative system designs can lower the cost of installation of GHPs.

Improvements should address key barriers that contribute to the high cost of GHP installation and operation, as well as increase the overall energy savings of using GHPs in lieu of conventional heating and cooling systems.

Grant applications should (1) thoroughly describe the proposed system design or component and how it relates to GHP development; (2) show a sound technical approach to accomplish the proposed R&D objectives through a well developed project plan, (3) show feasibility of proposed work through credible engineering calculations and existing quantitative data, (4) show that applicant and participants are capable of comprehensively addressing all aspects of the proposed project, (5) show level of participation by project participants as evidenced by letter(s) of commitment.

Grant applications are sought in the following subtopics:

a. High Temperature Downhole Logging and Monitoring Tools—Challenging subsurface conditions are one of the barriers to an accelerated ramp-up of geothermal energy generation. To address this challenge, grant applications are sought to develop logging and monitoring tools that are capable of tolerating extreme environments of high temperatures and pressures. The instruments of interest include, but are not limited to, temperature and pressure sensors, flow meters, fluid samplers, inclination and direction sensors, acoustic instruments (high and low frequency), resistivity probes, natural gamma ray detectors, epithermal neutron scattering gauges, rock density gauges (gamma and sonic), casing monitoring devices (e.g. cement bond logs and casing collar locators), fluid conductivity, pH indicators and well dimension probes (caliper). The target temperatures and pressures for these logging and monitoring tools should be supercritical conditions (374° C and 220 bar for pure water), and the tools may be used at depths of up to 10,000 meters.

Questions – Contact Raymond Fortuna, 202-586-1711, raymond.fortuna@ee.doe.gov.

b. Cements for EGS Applications—While conventional geothermal wells experience large temperature rises during production, EGS wells experience large temperature drops at the bottom of the well during the stimulation process, due to the cooling effect of the injected water. This temperature drop may be in the neighborhood of 350°F. This unique situation causes significant stress and potential failure of the cement sheath if conventional cement systems are utilized. To address this issue, grant applications are sought for the research, design, development, testing, and demonstration of a cement system for the high temperature and stress conditions of an EGS wellbore. Proposed approaches may define cement formulations that would be used by the geothermal industry to place the cement within a long string of casings; such approaches should focus on preventing a premature set and maintaining a strong seal at the shoe (so that stimulations may be performed through the casing).

Questions – Contact Raymond Fortuna, 202-586-1711, raymond.fortuna@ee.doe.gov.

c. Drilling Systems—High upfront costs, largely due to high drilling costs, are a major barrier to expanded geothermal energy production in the United States. Therefore, grant applications are sought to reduce drilling costs by developing a drilling technology (horizontal and/or directional) that is capable of drilling three times faster than conventional rotary drilling. Approaches of interest include, but are not limited to the design and development of improved drilling fluids (to reduce frictional viscosity and remove cuttings), high-performance bottom-hole assemblies (e.g., collars, bent subs, drill bits), and downhole motors (to control wellbore orientation). Proposed approaches must demonstrate reliable operation and equipment durability that exceeds the performance of conventional equipment at depths up to 10,000 meters and temperatures up to 300^{o} C.

Questions – Contact Raymond Fortuna, 202-586-1711, raymond.fortuna@ee.doe.gov.

d. Fracture Characterization Technologies—Subsurface imaging is an important part of creating a productive EGS reservoir, which requires visualization before, during, and after creation. In order to advance technology and reduce the upfront risk to geothermal projects, more robust subsurface imaging technologies must be developed. Grant applications are sought to develop improved downhole and remote imaging methods to characterize fractures. Fracture characterization includes prediction of fracture and stress orientation prior to drilling (needed to properly orient horizontal wells); determination of fracture location, spacing, and orientation (while drilling); and determination of the location of open fractures (after stimulation), in order to identify the location of fluid flow pathways within the enhanced geothermal reservoir. Proposed approaches should address robust methods for interpreting and imaging the subsurface, including but not limited to, the development of active or passive seismic, processing software, and joint inversion of geophysical techniques.

Questions – Contact Raymond Fortuna, 202-586-1711, raymond.fortuna@ee.doe.gov.

e. Working Fluids for Binary Power Plants—Binary power plants are rapidly becoming a major part of the geothermal industry, due to increased development of lower temperature geothermal resources. To address cost barriers associated with the working fluids in these binary power plants, grant applications are sought to (1) identify non-azeotropic mixtures of working fluids for improved utilization of available energy in subcritical cycles; (2) characterize the composition and thermophysical and transport properties of those mixtures; (3) identify working fluids for supercritical cycles and trilateral cycles; and (4) characterize the composition, thermophysical, and transport properties of those working fluids. Proposed approaches may address working fluids or mixtures of working fluids with the potential for greater energy conversion efficiency than conventional working fluids, such as isobutane or refrigerants.

Questions – Contact Raymond Fortuna, 202-586-1711, raymond.fortuna@ee.doe.gov.

f. GHP Component R&D—High initial costs have been identified as a key barrier to widespread GHP deployment. To address this barrier, applications are sought to improve GHP components to increase efficiency as well as energy savings as compared to conventional systems. Applications may address but are not limited to: variable-speed (VS) components, advanced sensors and controls (including water flow sensing), electronic expansion valves, heat exchange (HX) design and fluids, system optimization, unit control algorithms, and load management tools.

Questions – Contact Raymond Fortuna, 202-586-1711, raymond.fortuna@ee.doe.gov

g. Innovative System/Loop Designs—One of the main barriers in GHP technology is the high cost of drilling and loop installation. Applications are sought for innovative system/loop designs that reduce the costs of system and/or loop installation, through new design layouts, system components, materials, and/or methods.

Questions – Contact Raymond Fortuna, 202-586-1711, raymond.fortuna@ee.doe.gov

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5. PRODUCTION OF BIOFUELS FROM CELLULOSIC BIOMASS

Numerous biofuels development initiatives are underway to break the United States' dependence on the use of imported petroleum for producing various liquid transportation fuels. The Energy Independence and Security Act of 2007 (EISA) specifies a target quantity of 36 billion gallons of renewable fuels (Renewable Fuels Standard, or RFS) to be produced annually in the U.S. by 2022. Of this amount, 15 billion gallons is to be provided by conventional corn-starch-based ethanol with the other 21 billion gallons coming from advanced biofuels. Of this 21 billion gallons, 16 or more billion gallons is to be provided by cellulosic ethanol and the balance from other advanced biofuels.

To achieve these goals, it is essential to ensure that cost competitive feedstocks – of appropriate quality for biofuels production – are widely and sustainably available in sufficient quantities. Because the feedstock cost is a major elements in the production of biofuels, research is needed to ensure the cost-effective supply of major biomass resources to biorefineries, so that they can be converted to biofuels and bioproducts. This topic seeks the development of technologies to ensure this feedstock supply and includes the production of diesel fuel substitutes via microalgae production, biochemical pathways for the utilization of cellulose and hemicellulose to produce ethanol, and the thermochemical conversion of biomass to liquid transportation fuels such as ethanol, mixed alcohols, and advanced hydrocarbon-compatible and infrastructure-ready biofuels.

Process economic considerations suggest that processing of lignocellulosic materials would occur at large scales in integrated "biorefineries" producing multiple products. Grant applications are sought for new concepts and tools that will stimulate innovation and progress towards the realization of highly efficient and economically viable biorefineries producing liquid fuels and products from lignocellulosic biomass. **Grant applications are sought only in the following subtopics:**

a. Biomass Moisture Management and Drying—The preservation of feedstock, with respect to both quality and quantity, is critical to the development of the lignocellulosic feedstock supply chain that is needed to support a renewable biorefining industry. Given the short harvest window for biomass, in contrast to biorefineries that are continuously operational, the need to provide aerobically-stable feedstock is critical to meeting the demands of a cellulosic biofuels industry. However, a large portion of the available biomass in the U.S. will be wet at the time of harvest (Hess et al., 2006), and feedstock moisture adversely affects all elements of the supply chain (collection, storage, preprocessing, handling, and transportation). In addition to the cost associated with the transport of wet material, wet biomass is subject to an inherent instability, which makes it prone to microbial degradation and subsequent dry matter loss.

Biomass is considered dry when it is at or below 20-25% moisture (Shinners et al., 2007); however, the moisture content of corn stover at grain harvest reportedly ranges from 20% to 65% w.b. (Shinners et al., 2003; Hoskinson et al., 2007). Although drying methods are often employed to mitigate the negative impacts of unstable wet material on the supply chain, the process of drying is energy intensive, may increase biomass recalcitrance for conversion to biofuels, and comes at a significant cost to the supply chain. For example, the U.S. Corn Belt leads the nation in propane expenditures, used extensively for crop drying (Schnepf 2004).

Grant applications are sought to develop sustainable and efficient methods for drying/stabilizing biomass. Drying approaches must be applicable to woody, herbaceous, and other forms of cellulosic biomass. Of particular interest are (1) drying methods that enable value-added co-products to be recovered, thereby providing cost offsets to the supply chain, and (2) drying methods (or other methods for biomass stabilization/moisture management) that do not lead to an increase in biomass recalcitrance. Proposed drying/stabilization approaches should provide data on energy and material balances, capital and operating costs, and quality of preserved biomass (recalcitrance, composition, etc.).

b. Least-Cost Biomass Format for Efficient Logistics—Raw biomass at the time of harvest has a low bulk density ranging from 3 to 10 pounds of dry mass per cubic foot (10 lb/ft^3). The low end of the bulk density range represents a completely unpackaged biomass. The higher end represents that of a chipped or ground biomass. A further increase in bulk density requires a higher packed biomass. Examples of higher packing include pellets, cubes, and logs:

- Biomass pelletization is an extension of animal feedstuff pelletization. Pellet mills arose in the early 1940s for densifying ground feeds to a dense granulated form for easy blending with other ingredients. Pellets are extruded through a series of cylindrical holes, which make them available in the form of solid cylinders. To form these pellets, a pressure of about 2000 psi is necessary without using a binder. Pellets made from ground biomass have a density of 70 lb/ft^3, which can yield a bulk density of about 40 lb/ft^3. This high bulk density may be suitable for some types of long distance transport, such as rail and barge, which have high load limits. However, transport trucks have a road weight limit; thus, a bulk density larger than 15 lb/ft^3 will leave unused volume in the truck, making truck transport uneconomical.

- Cubing arose in the 1960s as a way of compacting larger biomass particles into a solid mass. Compared to pellets, individual cubes have a lower density, ~40-50 lb/ft^3, which results in a bulk density of approximately 20-25 lb/ft^3. The biomass is shredded (not ground, as for pellets) and extruded through a roll-die. The cubing process requires a binder, as the pressures are not that high and particles are not as small as those in pellets. Cubes can be stored and handled similar to pellets, but cubes do not flow with gravity as pellets do. Also, cubes are more susceptible to breaking during handling.

- Logs are densified biomass that are larger than cubes. The diameter of logs reaches 4 to 6 inches. Logs are produced by pressing ground biomass through a single die, often circular in cross section. Pressure is applied by pushing a piston against a slug of material in the die, which produces a continuous packed material. Long logs are cut to lengths for specific applications.

The full operation of making densified biomass consists of receiving, shredding, sorting, drying, grinding, densifying, and curing. Each of these unit operations contributes to quality and cost of the densified product. To reduce the cost, these individual operations must be analyzed and opportunities to reduce costs must be identified. The economics of making pellets, cubes, and logs are described in Mani et al. (2006), Sokhansanj et al. (2007), and Nielson (2004), respectively. These costs have not yet been optimized to determine what would be the least cost processes for these operations.

Grant applications are sought to develop the most optimum form and shape of biomass for low cost storage and handling. Proposed approaches could involve the development of new equipment, or the use of conventional equipment that offers alternate biomass formats. Grant applications must clearly identify all cost components in the production and handling of densified biomass. Although the approach may address one piece or several pieces of equipment, or one or several processes, the entire production must be feasible and commercially viable.

c. Separation Technologies for Biochemical Conversion of Lignocellulosic Feedstocks— Over roughly the past two decades, all major processing steps involved in biochemically converting lignocellulosic biomass to fuel ethanol – hemicellulose hydrolysis, cellulose hydrolysis, and biomass sugar fermentation – have been demonstrated to be technically feasible. However, the conversion of cellulosic materials remains slower and more capital intensive than traditional conversion methods for starch- and sugar-based feedstocks (i.e., “first generation” approaches). Underlying reasons include the higher solids content (and thus the need to operate under more dilute conditions), the slower cellulose hydrolysis and sugar fermentation rates, and the lower product titers typically encountered when processing cellulosic feedstocks. These attributes present particular challenges for separation processes, especially for membrane-based systems. Nonetheless, advances in separations technologies could offer potentially attractive substitutes for conventional separations techniques, such as distillation and evaporation, which are capital and energy intensive

Grant applications are sought to develop advanced separations technologies – including, but not limited to membrane-based approaches – that can be integrated into the biorefining operations of cellulose-derived biofuels, in order to reduce process energy and (net) water usage, and thereby reduce the cost and life cycle impacts. Proposed approaches should permit cost reduction and rate intensification of biochemical cellulose conversion processes, as well as improve the ability to economically fractionate conversion process streams. Approaches of interest include the development of methods that enable more efficient solid-liquid contacting; lower cost, higher efficiency methods of recovering solids from concentrated process slurries; and lower cost methods for washing and dewatering of lignocellulosic feedstocks, process intermediates, products, and residues.

Grant applications also are sought for process intensification methods that exploit reaction engineering principles, such as *in situ* separation (again, including but not limited to membrane-based approaches), to remove inhibitory components or products (e.g., alcohols, acids, salts) and thereby facilitate higher reaction rates and the attainment of high reaction yields.

d. Oil Extraction from Microalgae—Microalgal cells typically contain triacylglycerides (TAGs) in the form of lipid droplets within the cell. In order to become accessible for fuel production, this lipid must be extracted from the cell and purified away from other cellular components. Under the Aquatic Species Program at the National Renewable Energy Laboratory, solvent extraction has been the method of choice for removing and collecting this hydrophobic material. However, concerns over cost, scalability, and environmental hazards associated with solvents such as hexane may limit this approach. Therefore, grant applications are sought to develop innovative technologies for extracting the lipid droplets from microalgal cells, thereby enabling the cost-effective production of lipids as a feedstock for biodiesel or other biofuels. The preferred extraction system will (1) be relatively inexpensive, consuming no more than 15% of the energy in the final product; (2) be applicable to wet biomass streams in order to obviate the cost and energy expenditure of a drying step; (3) be able to extract primarily TAGs, although methods that also extract membrane lipids (phospholipids, glycolipids, etc.) would be beneficial, as this source of fatty acids may be too significant to be left behind; (4) result in a relatively clean oil stream with minimal contaminants such as protein and pigments; (5) be adaptable to a wide variety of algal strains with different cell wall chemistries, and (6) be readily scalable to accommodate very large algal cultivation/processing facilities.

Approaches of interest can include "green" solvents, supercritical CO_2 extraction, mechanical extraction, or other innovative methodologies. Proposed approaches may include subsequent purification steps to achieve the desired purity, provided that the cost targets still can be met.

Grant applications must demonstrate (1) cognizance of how the proposed technology fits within the overall process, and (2) the proposed technology's impact on the economics.

e. Pyrolytic Conversion of High Moisture Content Biomass to Bio-Oil—Thermochemical technologies for converting biomass to biofuels typically require dry biomass feedstocks with moisture contents of approximately 10% or less by weight. High-moisture biomass feedstocks (those with water contents of 70% or greater of the total weight of the biomass) usually require drying prior to conversion, and the drying step both uses significant amounts of energy and also increases processing costs. Examples of high-moisture feedstocks include but are not limited to the lignin-rich residues from a cellulosic fermentation biorefinery, residuals of microalgae after lipids are extracted, macro algae, cyanobacteria, and others.

Pyrolytic liquefaction potentially can convert wet cellulosic biomass to liquid transportation fuels. The initial liquefaction step converts the biomass to a crude bio-oil that would be a blend-stock for a petroleum refinery. Athough previous research has demonstrated that wet biomass can be liquefied to form a bio-oil, a number of issues have prevented economic feasibility: (1) many liquefaction systems require high pressure processing, which adds costs; (2) in some cases, significant quantities of the biomass are converted to low-value acids and related products that partition into the aqueous phase rather than the bio-oil, thus reducing the eventual yield of the transportation fuel; and (3) mineral matter carryover into the bio-oil further prevents its utilization.

Grant applications are sought to determine the technical and economic feasibility of innovative pyrolytic methods for converting multiple high-moisture cellulosic biomass feeds into bio-oils that are suitable as a petroleum refinery blend-stock. Proposed approaches (1) can use catalytic or other thermal processing approaches to cost-effectively convert high moisture biomass to bio-oil; (2) should produce high yields of bio-oil at moderate temperatures of ~450 C or less; (3) should focus on innovative processing concepts that develop measurable improvements in economics, compared to previous processes; (4) must clearly characterize and minimize the mineral carryover into the bio-oil products; and (5) be capable of converting both the carbohydrate and lignin portions of the feedstock to bio-oil.

Cellulosic biomass feedstocks used in this research must have the potential to be available in sufficient quantities, in order to have significant impact on liquid fuels. The use of food-based biomass such as grain, vegetable, or protein food-products will not be considered responsive.

f. Distributed Sorted Municipal Solid Waste Conversion to Biofuels—In 2007**,** 137.2 million tons of Municipal Solid Waste (MSW) went to landfills in the U.S. Organic materials are the largest component of MSW. In 2007, paper and paperboard accounted for 33 percent, with yard trimmings and food scraps accounting for 25 percent. While significant improvements have been made in the amount of recycling and combustion for heat, significantly more could be done to reduce landfills and municipal solid waste. One such opportunity is to use the organic MSW as a renewable feedstock for thermochemical conversion to a fuel, thereby reducing dependence on foreign oil while positively impacting landfills.

Thermochemical conversion processes, which include gasification and pyrolysis, are characterized by higher temperatures and faster conversion rates than typically observed in the biochemical conversion of feedstocks. Although thermochemical conversion is best suited for lower moisture feedstocks, it can readily convert the entire organic portion of various feedstocks to bio-intermediates and carbonaceous solids. Subsequently, the bio-intermediates can be converted to a range of biofuels such as mixed alcohols, Fischer-Tropsch fuels, green diesel, green gasoline, and green jet fuel. Therefore, grant applications are sought to develop a distributed thermochemical technology to convert several different compositions of sorted-MSW.

Proposed approaches must (1) identify which sorted-MSW materials would be most suitable for conversion; (2) deal with a myriad of impurities in the feedstock, which would require the development of extremely robust gasification and fuel synthesis catalysts (or pyrolysis and upgraded catalysts); (3) test the thermochemical conversion process and fuel synthesis catalysts with various sorted-MSW, in order to represent the variability of sorted-MSW in different regions of the country; and (4) ensure that emissions from the thermal conversion of sorted-MSW will meet all federal and local regulations. In Phase I, a small bench-scale system should be designed and tested with one type of sorted MSW to demonstrate feasibility. In Phase II, a demonstration modular unit should be tested with a markedly different sorted-MSW.

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3. Los Angeles County "Conversion Technology Demonstration Project – Overview: Conversion Technology Environmental Fact Sheet." (Full text available at: http://www.socalconversion.org/pdfs/Conversion_Technology_Environmental_Factsheet.pdf)

4. Boerrigter, H. and H. den Uil. "Green Diesel from Biomass via Fischer-Tropsch Synthesis: New Insights in Gas Cleaning and Process Design." Pyrolysis and Gasification of Biomass and Waste, Expert Meeting, Strasbourg, France, 2002. (Full text available at: http://www.senternovem.nl/mmfiles/28277_tcm24-124223.pdf)

6. ADVANCEMENTS FOR SUBCOMPONENTS CRITICAL TO ELECTRIC DRIVE VEHICLE POWER INVERTERS AND MOTORS

Electric drive vehicles such as hybrid electric vehicles and plug-in hybrids use electric traction drives to achieve reduced energy consumption and lower greenhouse gas (GHG) emissions. Electric drivetrain components, while already demonstrating significant on-road benefits in production vehicles, could achieve an even greater impact through further advancements in some of their critical subcomponents. The following technology areas represent critical barriers to the development and marketing of cost-competitive electric drive vehicles:

- Smaller, lighter, and less expensive capacitor materials that can meet the demanding high-temperature requirements of in-vehicle applications. Higher temperature tolerance also can reduce electronics cooling requirements and ease system integration challenges.
- New methods for producing permanent magnets used in electric motors. These magnets represent a significant portion of motor cost and improved production processes could significantly reduce the cost of motors and the energy required to create them.
- Advances in power electronics packaging concepts and integrated temperature measurement, including (1) improved high temperature packaging to reduce cost and improve performance in high temperature applications, and (2) approaches that measure internal semiconductor temperatures to improve reliability. Such advance could significantly improve the performance, reliability, and economics of efficient energy use in transportation.

Grant applications in response to this topic must show how the proposed innovations would result in significant advances in performance and/or cost reduction over state-of-the-art technologies. The general technical targets 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).

Grant applications are sought only in the following subtopics:

a. High-Performance DC Bus Capacitors for Power Inverters in Electric Drive Vehicles— DC bus capacitors have a direct impact on the overall size, cost, and performance of power system inverters for electric traction drives. However, the capacitors used in existing inverters occupy a significant fraction of inverter volume (≈35%), weight (≈23%), and cost (≈25%). Capacitors for automotive applications must survive extreme environmental conditions; yet the performance and lifetime of presently available capacitors degrade rapidly with increasing temperature (coolant temperature of 105°C). Further development is required to reduce the size and increase the temperature of operation of one of the largest components in the power inverter, i.e., the DC bus capacitor.

Grant applications are sought to develop dielectric films that have the potential to reduce the size, weight, and cost of capacitors for inverters in electrically driven vehicles, while providing increased capacitance density and high temperature operation. Desired DC bus capacitor performance targets are described in Table 1. Proposed capacitors should be able to withstand exposure to under-hood temperatures of up to 150°C, be capable of handling high current under these harsh environments, and maintain performance for a lifetime of 15 years or 150,000 vehicle miles.

Grant applications must provide a clear discussion, based upon available data and theory, to support an assertion that the capacitor materials to be developed will offer acceptable performance at a low cost. Proposed projects should include a demonstration of the material's performance in laboratory samples at the end of Phase I and a plan to produce capacitors suitable for use in a power inverter by the end of Phase II.

Table 1. Desired capacitor performance targets

	Typical Capacitor Bank Requirements
Capacitance, µF	1000 ± 10%
Operating voltage, VDC	200 to 450
Peak transient voltage for 50 ms	700
Energy density, J/cm^3	≥0.2
Leakage current at operating voltage, mA	≤1
Dissipation factor, %	<2
Ripple current, amp rms	100 continuous
Transient ripple current, amp rms for 50 ms	300
Temperature range of ambient air, °C	-40 to +140
Volume requirement, l	≤1.2
Cost	≤$30
Failure mode	Benign
Life @ 80% rated voltage	>10,000 hr, 120°C

Questions – Contact Steven Boyd, 202-586-8967, steven.boyd@ee.doe.gov.

b. Alternative Production Techniques for Homogenous Magnet Alloys—Interior permanent magnet motors (IPM) are currently the design of choice for electric traction motors in vehicles. Both independent analysis and current motor design require that the magnets for the IPM be based on Nd-Fe-B in either the anisotropic sintered or anisotropic bonded form. Currently sintered magnets used in the IPM represent about 30% of the motor cost. The elemental components cost of the magnets is approximately 60% of the total magnet cost, with the rare earth (RE) metal content accounting for approximately 90% of that cost. About 10% of the magnet cost is associated with the preparation of the alloy from the elemental constituents. Thus, the combined cost of acquiring the RE metals and processing them into a magnet alloy represent a major fraction of the motor cost. To meet the cost goals for these motors, substantial reductions in materials costs must be achieved.

The end products of the RE mining and separation processes are individual RE oxides that must be reduced to a metal in order to form the magnet alloy. This reduction process may be carried out in a separate step to produce the rare earth metal and other separable reaction products, or as part of a process which produces the magnet alloy along with the other separable reaction products. In either case, the existing processes require a significant number of steps to separate the reaction products and prepare the final alloy for magnet manufacture. A summary of the various methods currently employed for the production of Nd-Fe-B magnet alloy has been presented by Gupta.

Grant applications are sought for new and innovative techniques for the production of homogenous magnet alloy for use in the manufacture of anisotropic sintered magnets. The process should start with the separated rare earth oxide and should result in a final magnet alloy that is ready for conversion to powder and processing into anisotropic magnets. The process should reduce alloy costs and emphasize minimum energy input and waste stream production. Proposed approaches must (1) provide thermodynamic calculations to validate the process, (2) analyze the total energy consumption of the proposed process in contrast to existing methods, (3) present secondary processes for recycling reactants, (4) analyze the potential environmental impact of the process, (5) complete a cost analysis of the process, and (6) demonstrate laboratory-scale function of the critical process steps.

Questions – Contact Steven Boyd, 202-586-8967, steven.boyd@ee.doe.gov.

c. High Temperature Packaging—A concerted effort is underway by automotive manufacturers to reduce costs in electric drive systems 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 105 C at the inlet to the power electronics. Assuming a lifetime of approximately 15 years under these conditions, the power components must 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 electric drive vehicles, 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 wire bonds, and reduced volume, while allowing for high current density and a minimization of the 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, and provide for close matches between the coefficients of thermal expansion (CTEs) of the packaging materials; (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. Proposed approaches should lower high-volume manufacturing costs, with particular attention given to the availability and cost of lead-free high-temperature solders, and to the effects of solder fatigue in the package over extended operation.

Questions – Contact Steven Boyd, 202-586-8967, steven.boyd@ee.doe.gov.

d. Non Obtrusive Semiconductor Die Temperature Measurements—An increasing need exists, both in research applications and in commercial power electronics, to accurately determine die junction temperatures. The 'real time' temperature determination of internal device temperature characteristics would aid in the evolution of new packaging concepts as well as in reliability determinations and assessments. Also, drive control algorithms can be optimized, and device and module failures mitigated, through the utilization of temperature data. The incorporation of temperature sensors onto the semiconductor device – to enable accurate measurements of maximum temperatures, as well as the conditions and parameters under which they are present – could lead to the optimization of both device- and module-level cooling, thereby realizing cost saving.

Therefore, grant applications are sought to develop means of accurately determining die junction temperatures at the device level. Of particular interest are approaches that provide the thermal performance of the device using die-attached methods that require no external circuitry or components. The primary devices of interest are Insulated Gate Bipolar Transistors for power electronic switches in traction motor drives. However, methods that are translatable for other types of semiconductors are encouraged.

Questions – Contact Steven Boyd, 202-586-8967, steven.boyd@ee.doe.gov.

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Subtopic a - High-Performance DC Bus Capacitors for Power Inverters in Electric Drive Vehicles

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Subtopic b - Alternative Production Techniques for Homogenous Magnet Alloys

1. C.K. Gupta and N. Krishnamurthy, Extractive Metallurgy of Rare Earths, Boca Raton, Fl., CRC. Press, (2005). (ISBN: 0-415-33340-7) (Full text available at: http://www.tms.org/pubs/journals/JOM/reviews/52.htm)

Subtopic c - High Temperature Packaging

1. Charles A. Harper. Electronic Packaging and Interconnection Handbook, 3rd Edition. (ISBN 0-0713-47453) (Full text available at: http://www.amazon.com/Electronic-Packaging-Interconnection-Handbook-Charles/dp/0071347453/ref=sr_1_1?ie=UTF8&qid=1252068447&sr=8-1)

2. James J. Licari and Leonard R. Haber. Hybrid Microcircuit Technology Handbook, Materials, Processes, Design, Testing and Production, 2nd Edition, Noyes Publications. (ISBN 0-8155-14239) (Full text available at: http://www.amazon.com/Hybrid-Microcircuit-Technology-Handbook-Second/dp/0815514239/ref=sr_1_1?ie=UTF8&s=books&qid=1252068498&sr=1-1)

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

7. WIND ENERGY TECHNOLOGY DEVELOPMENT

In July 2008, the U.S. Department of Energy (DOE) published the results of a report entitled 20% Wind Energy by 2030: Increasing Wind Energy’s Contribution to U.S. Electricity Supply. According to the report, the United States has more than 8,000 gigawatts (GW) of available land-based wind resources that could be captured economically. Under the 20% wind energy scenario, the industry could support 500,000 jobs by 2030, 180,000 of which would be directly related to the industry through construction, operations, and manufacturing.

Although achieving 20% wind energy would have significant economic, environmental, and energy security benefits, the industry must overcome significant challenges to make this goal a reality. In particular, the transmission infrastructure must be enhanced, U.S. manufacturing capacity must be increased, siting and permitting requirements must be streamlined, and the reliability and operability of wind systems must be improved. To address these challenges, the DOE Wind Program and the national laboratories collaborate with federal, state, industry, and stakeholder organizations to lead wind-energy technology research, development, and application efforts.

This topic seeks to further advance the development of technologies to speed the commercialization of wind energy as a national resource. Grant applications must (1) thoroughly describe the proposed product, subsystem, or component and its potential benefits over current technologies; (2) to the extent feasible, demonstrate that the proposed approach, in a mature configuration, will have a net positive impact on wind turbine or overall wind plant cost of energy (COE) through performance enhancement or reliability, taking into account such long-term factors as maintenance, refurbishment, replacement, and recycling; and (3) establish a clear, realistic long-term plan for concept development, prototype fabrication, testing, and establishing the industry partnerships required for successful commercialization. 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. Manufacturing and Assembly—Innovative manufacturing and assembly tools and designs are needed to 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. With respect to manufacturing and assembly, 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. With respect to material development, approaches of interest include the development of processing technologies that will enhance the cost-effective domestic availability of the key materials needed to support advances in turbine technology, such as carbon fiber for rotor blades, innovative materials for taller towers, and permanent (rare earth) magnets for generators. These materials must be available in sufficient quantity, and at competitive prices, to meet the significantly increasing manufacturing needs. 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 long-term implications such as maintenance, refurbishment, replacement, and recycling.

Questions - contact Ronald Harris (ronald.harris@ee.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. Yet, some components – blades, for example – are difficult to inspect, due to their large size and thick sections. Therefore, improved inspection methods are needed to evaluate bonding quality, thick section infusion, and 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. These field methods are important for evaluating field repairs and equipment modifications. Methods that uncover hidden defects during the operational checkout phase are of interest, in order to 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 Michael Derby (michael.derby@ee.doe.gov).

c. Condition Monitoring—As wind energy systems increase their penetration into the national electrical power base, the 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. Proposed approaches should include (1) advanced sensor systems and instrumentation, and (2) models that can predict real-time performance and component failure – leading to a system capability for determining structural condition, reducing unscheduled outages, and predicting failures and maintenance needs before problems occur.

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@ee.doe.gov)

REFERENCES :

Subtopic a - Manufacturing and Assembly

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

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

Subtopic b - Component Reliability

1. John H. Gieske and Mark A. Rumsey. "Nondestructive Evaluation (NDE) of Composite/Metal Bond Interface of a Wind Turbine Blade Using an Acousto-Ultrasonic Technique", Sandia National Laboratories, SAND96-2506C, Albuquerque, NM. (Full text available at: http://www.sandia.gov/wind/asme/AIAA-97-0959.pdf)

2. Alan G. Beattie and Mark Rumsey. "Non-Destructive Evaluation of Wind Turbine Blades Using an Infrared Camera", Sandia National Laboratories, SAND98-2824C, Albuquerque, NM. (Full text available at: http://www.sandia.gov/wind/other/982824c.pdf)

Subtopic c - Condition Monitoring

1. Charlie Hatch. "Improved Condition Monitoring Using Acceleration Enveloping", 2Q04 ORBIT, pp. 58-61, (2004). (Full text available at: http://www.gepower.com/prod_serv/products/oc/en/orbit/downloads/2q04windturbcondmon.pdf)

2. T. W. Verbruggen. "Wind Turbine Operation & Maintenance Based on Condition Monitoring: WT-OMEGA," ECN (Energy research Center of the Netherlands) Final Report, Jan. 2003. (Full text available at: http://www.ecn.nl/publications/default.aspx?nr=ECN-C--03-047)

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

Energy storage technology 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, high power cycles with a 15 year calendar life. The specific energy (Wh/kg) of most current batteries is not sufficient to meet the weight and volume goals for PHEVs.

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 relative to the materials currently in vehicular batteries, 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 are sought only in the following subtopics.**

a. Technologies that Allow the Use of a Lithium Metal Negative Electrode in a Rechargeable Cell—Grant applications are sought to increase the energy density and specific energy of PHEV batteries by developing technologies that will allow the use of a lithium metal negative electrode in such a battery. At a minimum, a technology must allow the electrode to be deeply cycled at least a thousand times, without significant loss of active lithium and without the formation of lithium dendrites that might short the cell. The goal for a PHEV battery is 5000 such cycles. The technical effort should focus on stabilizing the lithium surface under the cycling conditions that would be found in a vehicular battery. (The electrode must be able to charge and discharge at rates that are appropriate for a PHEV application.)

Grant applications must: (1) identify the nature of the electrochemical couple in which the electrode would be used (i.e., identify the positive electrode and electrolyte); (2) provide a theoretical basis for the research; (3) address the probable cost of using the technology in vehicular batteries relative to current technologies; (4) address the impact of the technology on all performance parameters and discuss approaches to mitigate any adverse effects on other performance requirements (e.g., power, performance over a range of temperatures, cost, cycle life, calendar life, and abuse tolerance); and (5) propose a Phase I project to demonstrate the technology by cycling a lithium metal electrode in a laboratory cell. In Phase II, the cycling shall be demonstrated on a scale and under conditions appropriate to a vehicular battery.

Questions - contact James Barnes, 202-586-5657, (james.barnes@ee.doe.gov)

b. Multi-Electron Redox Materials for High Energy Batteries—One way to increase the energy density and specific energy of a battery is to use an electrochemical couple in which the active materials in one or both electrodes undergo multiple electron redox reactions. Grant applications are sought to develop materials/systems that can undergo reversible, multi-electron redox reactions and to demonstrate these materials/systems in rechargeable cells. Grant applications shall (1) describe the active material(s) to be developed; (2) identify the other major components of the cell (counter electrode, electrolyte, etc.); (3) provide a description of how the cell would function; (4) relative to state-of-the-art lithium-ion cells, discuss the potential improvements in energy content of the new electrode material(s) and of a cell using the new materials; and (5) discuss other expected characteristics of the new materials/systems, including their power capability, performance over a range of temperatures, cost, cycle life, calendar life, abuse tolerance, and ease of processing. Proposed approaches to develop new materials that would result in significantly poorer performance, relative to the state-of-the-art, in one of these characteristics may be deemed to be non-responsive. In Phase I, the proposed materials/systems shall be demonstrated in laboratory cells with a capacity of 100 mAh or larger. In Phase II, the proposed materials/systems must be incorporated into and demonstrated in cells appropriate for use in a PHEV.

Questions - contact James Barnes, 202-586-5657, (james.barnes@ee.doe.gov)

c. **Technology to Allow the Recovery and Reuse of "High-Value" Materials from Used Lithium-Ion Batteries**—The introduction of electric drive vehicles into the marketplace will be accelerated by technologies that reduce the total life-cycle cost of their batteries. The recovery and processing of "high value" materials, such as electrode materials from used lithium-ion batteries, to yield materials that could be used in new batteries is one way to reduce total life-cycle costs. (For the purposes of this topic, an example of a "high value" material would be $LiCoO_2$, which could be used in a new cell; a "lower value" material would be a cobalt oxide that only could be used in a cell after undergoing a conventional synthesis process to produce battery grade $LiCoO_2$..) Such recovery and reuse could increase the residual value of a used battery and could provide materials for new batteries at a lower cost than if those materials were synthesized from normal starting materials. Therefore, grant applications are sought to develop and demonstrate technologies that would enable (1) the recovery of active materials from used lithium-ion batteries, and (2) the processing of these materials so that they might be used in new batteries. Grant applications must address the probable cost of the proposed technologies. If there is no cost advantage relative to the new materials, the grant application may be deemed non-responsive. Proposed technologies that enable the recovery of the maximum quantity and variety of material(s) from a cell are preferred. Technologies that focus on the recovery of elemental materials (e.g., cobalt metal) or that result in a significant portion of the incoming batteries being reduced to "slag" will be deemed non-responsive.

In Phase I, the recovery and processing technologies may be demonstrated on small quantities of similar cells, and the capability to reuse the materials shall be confirmed in cells of at least 200 mAh in size. Phase II must address the processing of large quantities of cells of multiple chemistries and demonstrate the performance of the recovered materials in cells of at least 2 Ah in capacity.

Questions - contact James Barnes, 202-586-5657, (james.barnes@ee.doe.gov)

d. New Electrolytes for Lithium-ion Cells—Most commercial lithium-ion cells use an electrolyte containing a mixture of organic carbonate solvents. When combined with $LiPF_6$ and other additives, these solvents represent the state-of-the-art for electrolytes. But these electrolytes suffer from several potential weaknesses: (1) the solvents are quite flammable, (2) $LiPF_6$ is quite reactive with the other materials in the electrolyte and with impurities such as water, (3) no one mixture of the solvents has been shown to work well at both low and high temperatures, and (4) the electrolytes appear to be reactive with the surfaces of standard cathodes and to be unstable at high voltages.

Grant applications are sought to develop and demonstrate new electrolytes for lithium-ion cells that are not based on organic carbonate solvents (although relatively small quantities of these carbonates may be incorporated in the new electrolytes.) Grant applications shall (1) describe the components of the new electrolytes, including their primary solvents, salt(s), and additives;

(2) identify what lithium-ion electrode pair (anode and cathode) will be used with the electrolyte; (3) explain the benefits expected to be derived from the use of the new electrolyte; and (4) discuss the expected performance of cells built using the new electrolyte. Performance criteria of concern include power, energy, cycle life, calendar life, cost, operating temperature range, abuse tolerance, etc. Proposed approaches that would result in cells that perform significantly more poorly than state-of-the-art lithium-ion cells may be deemed non-responsive. Phase I shall involve the demonstration of the materials in laboratory cells of at least 200 mAh. In Phase II, the materials must be incorporated into and demonstrated in cells appropriate for use in a PHEV.

Questions - contact James Barnes, 202-586-5657, (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. (URL: 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.

9. TRANSITIONAL TECHNOLOGIES FOR SOLID STATE LIGHTING

The DOE, in collaboration with the Next Generation Lighting Industry Association (NGLIA), domestic university researchers, industry stakeholders, and other federal agencies, has established aggressive yet obtainable goals for Solid-State Lighting (SSL). 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 bold, multifaceted program has been developed that includes both basic "core" research as well as more applied "product" research. A comprehensive overview of the technical and commercialization opportunities associated with the DOE's SSL activity is available at http://www1.eere.energy.gov/buildings/ssl/. This topic seeks to advance key enabling or transitional research prospects as described below.

Although grant applications submitted to this topic need not include a detailed commercialization plan, all applicants must completely describe (1) how the anticipated intellectual property or other project deliverable would be made available for license or for subsequent use to an existing or potential SSL device manufacturer or (2) how the subject technology would be used to support an existing business relationship or a commercialization partner. In addition, grant applications must include detailed, quantitative supporting information to substantiate the anticipated benefits to the SSL activity; these benefits may include cost or performance improvements commensurate with those of the multi-year program plan (MYPP), which is available for download at http://www1.eere.energy.gov/buildings/ssl/techroadmaps.html.

Grant applications are sought only in the following subtopics:

a. Transitional Technology for Light Emitting Diodes (LEDs)—The DOE has identified a number of key technical issues that are thought to impact the attainment of the DOE's goals for SSL. Many of these have been identified in various SSL workshops held nationwide as high priority research areas of interest, and they have been the subject of prior solicitations (http://www1.eere.energy.gov/buildings/ssl/financial.html). Some are described fully in the MYPP. Examples of these previously identified "core" research issues include the need to (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 lifetimes and cost competitiveness for LEDs; by employing advanced designs, device architectures, or novel manufacturing methods, including die growth or alternative substrate materials. Grant applications are sought that might have a positive and lasting impact on the success of the SSL activity. Proposed approaches may specifically address one or more of the aforementioned areas of interest or may address other technologies that might produce meaningful results of programmatic interest, such as optical modeling, alternative device architectures or materials systems, advanced thermal management schemes, or active power distribution. Grant applications must completely describe how the proposed technology will produce the desired improvements in performance or cost, consistent with the objectives enumerated in the MYPP.

Questions – Contact Richard Orrison, 202-586-1633, Richard.Orrison@ee.doe.gov.

b. Transitional Technology for Organic Light Emitting Diodes (OLEDs)— Both small molecule and polymer OLEDS intended for SSL applications possess certain performance and manufacturing limitations, particularly when operated at the high current densities required for general illumination applications. These limitations are thought by many to impede their acceptance as viable light sources. A variety of new materials and architectures of OLEDs have been proposed to overcome these limitations, and the DOE has supported many of these approaches under prior awards, many of which have met the significant performance challenges, including efficacy, set forth in the MYPP. Some of these novel materials and systems have already demonstrated that indeed, OLEDs may one day compete with LEDs for SSL market share. Still, OLEDs lag behind LEDs in product development and in particular, cost effective manufacturing. Therefore, grant applications are sought to advance candidate OLED devices for general illumination applications, which require brightness in the range of 1000 cd/m^2 for prolonged periods of time (>10,000 hours) and operation in hot environments (such as in the ceilings of commercial buildings, where temperatures can exceed 125 C). Proposed approaches should seek to achieve performance levels set forth in the MYPP and beyond, by producing improvements in blue light performance (spectrum, efficacy, and lifetime), charge injection and balancing, electrode materials (reflectivity, transparency, and conductivity), device stability and layer compatibility, out-coupling enhancements, and thermal management. Grant applications may address any of these areas or any other technical transitional area, provided sufficient justification is made relative to the price and performance goals of the MYPP.

Grant applications are also sought to develop new, low cost manufacturing technologies to support the anticipated high volume manufacturing of OLEDs on flexible substrates or thin glass.

Questions – Contact Richard Orrison, 202-586-1633, Richard.Orrison@ee.doe.gov.

c. "Supporting Technologies for Off-Grid SSL Applications—There are many reasons why SSL is a good match for off-grid general illumination applications including signage. The energy conservation potential stems from removing lighting loads entirely from the power grid and powering them directly from renewable energy sources such as solar or wind. SSL devices that are not as efficient as those required for lighting in and around U.S. buildings may be perfectly suited to off-grid applications. Other advantages of off-grid lighting applications include the prospects of (1) using low power devices in remote locations, where reliable high voltage power from the grid is not economically available; or (2) taking maximum advantage of the inherent match of SSL operating voltage to photovoltaic (PV), wind, or other renewable energy sources.

While considerable success has already been realized worldwide in this area, it is thought by many that certain key technology challenges remain. These challenges include (1) the development of suitable hybrid systems that use appropriate and complementary renewable energy sources, including those targeted by DOE, such as the combination of solar and wind; (2) the commercial development of key components for advanced systems, including alternatives to costly and environmentally unfriendly lithium-ion batteries, non-imaging optics, inexpensive large area optics, etc.; and (3) the commercial development of supporting technologies that might enable more efficient, cost effective off-grid products, such as thermoelectric or other waste heat harvesting to reduce PV requirements or extend battery life. Grant applications are sought to advance these and other similar transitional technologies that will contribute to the wider use of off-grid solid-state lighting. Grant applications must identify a key technology area(s) for development and must include quantitative supporting information to justify exactly how the subject effort will advance the use of off-grid general illumination or signage. Proposed approaches that are duplicative of research and development sought and funded under other DOE programs – including the Solar America Initiative (SAI) (http://www1.eere.energy.gov/solar/) or various advanced battery programs (http://www1.eere.energy.gov/vehiclesandfuels/technologies/energy storage/index.html) – are not of interest and will be declined.

Questions – Contact Richard Orrison, 202-586-1633, Richard.Orrison@ee.doe.gov.

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10. ENERGY EFFICIENT MEMBRANES FOR INDUSTRIAL APPLICATIONS

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 standalone 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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11. 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 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@hq.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 and innovative, significant, and potentially commercially viable catalytic approach for lignocellulose conversion to a liquid fuel product.

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

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12. HYDROGEN SAFETY, STORAGE, DELIVERY, AND PRODUCTION

Enabling the technology development for widespread commercialization and use of hydrogen and fuel cell technologies for stationary, portable, and transportation applications, the Office of Science and the Office of Energy Efficiency and Renewable Energy work together to reduce petroleum use, greenhouse gas (GHG) emissions, and air pollutants, as well as contribute to a more diverse energy supply and efficient use of domestic energy. The following subtopics address key gaps in technology development. **Grant applications are sought only in the following subtopics:**

a. Materials and Processing for Lower-Cost High Pressure Gaseous Fuel Tanks— Inexpensive fuel storage for early market applications is critical to the widespread commercialization of fuel cells. Currently, depending on scale, near-term fuel cell applications rely on Type I storage vessels, which are made of thick walled steel. Grant applications are sought to develop low-cost gaseous hydrogen storage options for materials handling, specialty vehicle applications, as well as for large scale storage of energy from renewable sources. Approaches of interest include a broad range of materials and component development for cost reduction: carbon fiber cost reduction and alternative materials development such as glass fibers (30-75% of system cost), cost reduction of regulators (5-10% of system cost), valves (5-20% of system cost), and balance of plant (10-15% of system cost). In addition to materials development, tank testing and analysis to support component development should be included in proposed efforts.

Projects are requested which address one of the 4 topics listed above. Before tanks or components are built for testing, information must be provided regarding impacts of the technology on performance (g/L, g/kg) and cost ($/kWh) of the full tank system (fill port to power plant inlet). For example, information is needed regarding (1) the costs associated with glass fiber (protected via vacuum/low temperature or with coatings), low cost moderate strength carbon fiber from inexpensive precursors; (2) novel designs for hydrogen regulators, valves and sensors; and (3) cycling and testing of liners (polymer and aluminum) to prove cycle life and reduce material needs.

Phase I should focus on creating complementary strategies based on 1-3 to develop low-cost storage systems with higher capacity and lower cost than existing type I cylinders used for storage today. The Phase I project should include a detailed technical analysis comparing today's tank technology and options against proposed improvements, along with an economic analysis that uses standard financial metrics and includes all relevant capital and O&M costs involved with tank production and lifecycle costs. The cost comparisons should address opportunities for cost reduction, including, but not limited to, manufacturing fibers, valves, sensors, and tank assembly. The plan should be sufficiently comprehensive such that implementation of improvements could begin within several months after completion of the analysis and initial testing. Phase I should also provide a preliminary lifecycle cost analysis of overall energy use, and greenhouse gas emissions reduction due to the tank component improvements over existing technology (batteries, or other energy storage options).

Phase II would address scale-up and use of selected technology advancements and include actual tank designs, construction, and testing with a final report comparing forecasted and actual costs.

Questions – contact Monterey Gardiner, 202-586-1758, Monterey.Gardiner@ee.doe.gov.

b. Reducing the Cost of Fiber Reinforced Polymer –Pipelines—Inexpensive hydrogen delivery for early market applications is critical to the widespread commercialization of hydrogen fuel cells. Currently, hydrogen fuel cell systems may rely on onsite fuel generation or high pressure or liquid hydrogen delivery, which can be expensive. Options such as pipeline delivery are limited due to the current material and installation cost of stainless steel pipe.

Newer fiber reinforced polymer (FRP) pipe may provide a cost effective option for developing a hydrogen distribution infrastructure for these early market applications. However, before the FRP technology can move forward, information must be generated to improve the cost estimates and the performance of the technology.

Grant applications are sought to develop low-cost FRP pipeline materials options that will meet the DOE goals for hydrogen transmission in the Multi-Year Program Plan (MYPP). Approaches of interest include (1) lower cost pipeline materials development in any of the three categories (abrasion resistant coatings, reinforcement materials such as synthetic polymer, or glass fiber permeation barriers or pipeline liners); (2) the costs associated with the difference between conventional steel joining technology, which might not be compatible with high-pressure hydrogen, and a new joining technology based on glass or carbon fiber-reinforced composites in a unique design that provides better performance in a hydrogen environment; (3) Advanced manufacturing technologies such as mobile manufacturing capabilities or pipeline production at the trench; and (4) an outline of damage detection technologies, e.g. coatings which change color to indicate pre-installation damage and side-by-side signal wire that can detect post-installation damage.

Phase I should focus on creating complementary strategies based on any or all of the approaches of interest (1 through 4) to develop low-cost FRP pipelines. The Phase I project should include a detailed technical analysis comparing today's pipeline technology and options against proposed improvements, along with an economic analysis that uses standard financial metrics in the H2A analytical framework and includes all relevant capital and O&M costs involved with FRP pipeline production and lifecycle costs. The cost comparisons should address all aspects of installing FRP pipelines, including, but not limited to, manufacturing, placement of the pipelines, and monitoring health of the pipeline to end of life. The plan should be sufficiently comprehensive that acting on suggested improvements could begin within several months after the analysis and initial testing is completed. Phase I should also provide a preliminary lifecycle cost analysis of overall energy use, and greenhouse gas emissions reduction due to the pipeline improvements over existing technology.

Phase II would address scale-up and use of selected technology advancements that were identified in Phase I and would include actual pipeline designs and a proposed budget for installation of the pipeline and testing of the pipe before and after installation. The final report will compare the cost of the FRP pipeline enhancements with incumbent technologies.

Questions – contact Monterey Gardiner, 202-586-1758, Monterey.Gardiner@ee.doe.gov.

c. Hydrogen Odorant Technology—The human physical response to malodor has played an important role in public safety around flammable gases for over seventy years. Odorants in natural gas are a proven, cost-effective means for leak detection in commercial applications where the desired action upon detection is area evacuation. The challenges for adapting odorant technology to a hydrogen infrastructure are two-fold. The flammability range and high dispersion velocity of hydrogen require an odorant technology to work over a broader set of conditions than for traditional hydrocarbon fuel gases. The sulfur-containing odorants that are used for hydrocarbon fuel gases will not work in fuel cell technology because they adversely affect fuel cell and advanced storage performance.

Grant applications are being sought to develop hydrogen odorant technology that is compatible with the dispersion characteristics of hydrogen and is compatible with fuel cell and storage materials. The odorant chemical must be non-toxic and should be compatible with fuel cell technology (e.g. meet proposed fuel quality performance standards).

Phase I must provide a screening of candidate odorant chemistries that meet the following performance requirements:

- High dispersion velocity so that a hydrogen release is detectable over the flammability range;
- Stability over the range of pressures and temperatures found in vehicle and stationary fuel cell technology;
- Does not adversely affect fuel cell performance;
- Provides an olfactory response for tolerable odorant loadings;
- Meets life cycle cost goals.

A Phase II project would address durability of fuel cell systems and components (including fuel storage and delivery components) and develop the full set of technical information for fuel quality standards.

For more information please contact Antonio Ruiz, 202-586-0729, (antonio.ruiz@ee.doe.gov)

d. 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 several fuel cell applications. 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 standalone device, overall process efficiency could be enhanced.

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 (< 2000 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 (H2A), and then the estimate should be compared to existing technologies and to DOE cost targets (MYPP).

Phase II must scale and demonstrate the technology using a slip stream from a commercial operation in which a dilute hydrogen stream needs to be purified and compressed.

Questions – contact Rick Farmer, 202-586-1623, (richard.farmer@ee.doe.gov)

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13. 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. Often, detector concepts or protoypes already exist in the community, and the primary hurdle is commercialization. Therefore, proposed approaches that emphasize engineering for commercialization are also of interest.

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

b. Beam Diagnostic Instrumentation for Free Electron Lasers and 3rd Generation Light Sources—Advanced electron-beam diagnostic instruments are needed to support the development of X-ray Free Electron Lasers (FEL), as well as the operation and upgrade of 3rd generation light sources. Grant applications are sought to develop monitors for beam position and electron bunch length. The beam position monitor should have 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.

Grant applications also 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. Finally, grant applications are sought to develop high resolution multi-function diagnostics. Cavity beam position monitors (BPMs) which are well suited for LINAC applications as well as for advanced storage rings and energy recovery linacs (ERLs), represent one approach of interest. Such cavity BPM diagnostics should (1) have measurement capabilities that include sub-micron positioning, beam tilt, and charge; and (2) be physically small and low cost, in order to enable commercialization.

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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14. 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 sources, 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. Klystrons and Inductive Output Tubes (IOTs)—Grant applications are sought to develop higher order mode (HOM) inductive output tube (IOT) continuous wave (CW) amplifiers at 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 than current klystrons, with approximately 15-20% higher efficiency. An IOT that could operate at ~70% efficiency (a level now approached by television IOTs with depressed collectors) would result in significant energy cost savings. An IOTs that is tunable over a reasonable range also would be desirable.

Grant applications also are sought to develop a pulsed inductive output tube (IOT) amplifier at 402.5 MHz, 140 kW, and 10% duty factor for a low-energy bunching application for high power H-/proton beams.

Finally, grant applications are sought to develop a 2.815GHz CW klystron (~100kW), preferably with two output windows, that would be suitable for a superconducting RF cavity;

b. Gridded Tubes and Cavities—Grant applications are sought to develop a moderate power (10-50kW CW) tetrode cavity, tunable from 340 to 360MHz (or to possibly higher frequencies). Such a cavity would enable tetrodes or diacrodes to be competitive for sockets in superconducting cavity applications.

Grant applications also are sought for an analysis, as well as the development of tests and procedures, to demonstrate that superconducting cavities fabricated from niobium, for example, can meet federal pressure vessel safety requirements. Proposed approaches should include, for example, non-linear stress analysis, experimental tests, and modification of cool-down procedures.

c. Higher Order Mode Damper Integrated into Beam Pipes—Grant applications are sought for the integration of ferrites into beam pipes adjacent to RF cavities, in order to damp parasitic higher order modes. Although such a technique has been developed at accelerator laboratories, it never has been industrialized.

d. RF Cavity Input Couplers—Grant applications are sought to develop (1) a variable input coupler for both normal-conducting and superconducting 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; (2) a high power fundamental power coupler 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 5×10^4, and factor-of-10 variable coupling with minimum transverse kick to the beam; (3) an adjustable 20-way 40 kW CW power combiner operating at 352 MHz; and (4) a coaxial H-loop normal-conducting RF cavity input coupler for 352 MHz, which is capable of operation at 500kW forward power under infinite VSWR conditions and is compatible with a half-height WR2300 waveguide transition.

e. RF Power Devices and accessories— Grant applications are sought to develop (1) higher power Insulated Gate Bipolar Transistors (IGBTs) with more than 6000Volts and more than 2000Amps, which are required for the development of high power modulators and power supplies; (2) a very high power (100-400 kW) 350-500 MHz solid state power amplifier to replace klystron amplifiers in synchrotron light sources; (3) a compact, water-cooled broadband 50-ohm RF load that can operate at 200kW CW input power and is resistant to the corrosive effects of the high-purity, de-ionized water that is used as a coolant; (4) new dielectric materials for vacuum-barrier RF windows for high-power applications, in order to significantly improve the power handling capability and mechanical strength (compared to existing materials), and demonstrate a low secondary electron emission coefficient; (5) a compact, high-power stripline-input broadband R termination, which is capable of 1kW CW input power and could be used for board-mounted components such as circulators and splitters/combiners; and (6) 4-way resonant cavity RF combiners of IOT power sources (the output of several IOTs must be combined to overcome their low power capability) to drive accelerating structures for high energy and high intensity accelerators that require several hundreds of kW.

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

f. 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; (2) a robust, high-average-power (200kW) 1 kHz modulator system that operates at approximately 300 kV and 300 A, with an ultimate rep rate at 1kHz or higher; (3) a robust, high-average-power (1.4 MW or greater) 60 Hz pulse modulator system that operates with a duty factor of 10 percent at various voltage and current ratings (for example, 140 kV at 90 A, 85 kV at 165 A); and (4) a solid state modulator for 40kV, 300A, 1 micosecond pulses at 60 Hz.

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

g. Low Level Radio Frequency (LLRF) Accelerator Systems—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)

h. 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. Devices of interest include:

(1) Electromagnetic RF cavities operating in a dipole mode, which 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 wake fields.
(2) Pulsed power supplies that can be used with stripline kickers to provide deflecting fields. Such power supplies should have a repetition rate up to 100 kHz, a voltage pulse 10-15kV, a 10 ns pulse duration, and pulse-to-pulse stability better than $10^{-3.}$

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

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15. 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 sources, 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 a high repetition rate, using laser excitation. The 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 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 1.2 ms long pulses at 60 Hz. The current should remain constant within ~5%. The lifetime, as well as the mean-time-between-failure, should exceed several months. Of special interest are highly efficient ionization technologies that can produce such beams with moderate power levels (< 40 kW peak power) and use a minimum of cesium (<<1mg/day).

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 of 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) Superconducting undulators with time varying fields. This technology is in its infancy and could offer interesting possibilities for insertion-device radiation sources

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

(4) 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.

(5) 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, leading to the development of coil manufacturing techniques based on such materials (as the next step).

- Thin film high temperature superconducting materials such as MgB_2, which are operated at ~39K, may become a good material for undulator magnets, depending upon the choice of substrate material, which will determine the mechanical properties of the superconductor. The challenge here is the production of thin films and the choice of optimum substrate materials.
- APC (artificially enhanced pinning center) NbTi superconductor, which would allow super-high current densities that exceed the Jc of conventional NbTi superconductor by a large factor (14 kA/mm^2 at 2 T). In particular, the high current density might offer an advantage for the design of magnet coils for undulator magnets.

(6) Undulators with period < 1 cm. The resonant condition requires undulator radiation at short wavelength (approximately 1 nm), with low energy electron beams (of 1-2 GeV), and with a shorter period than generally available from existing synchrotron radiation sources. The undulators should be designed with K-value ~1, impedance shielding of pole faces, and a gap that is greater than 2.25 mm.

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

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16. 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 sources, 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 femtoseconds 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 kilometers, 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}) 750 MHz 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) and 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, 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 emittance growth due to space charge effect in a photoinjector. Approaches of interest 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 three dimensions, 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 100 fs, possibly CEP-stabilized in the energy range of a few mJ.

(5) Tunable lasers to be used as seeds for free electron lasers (FELs). The central wavelength should be within the wavelength range, 10-50 nm, and the laser should be continuously tunable within a band that is at least 20% of 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. The lasers should have high repetition rate (~400 MHz), high peak power (~1MW), and picosecond 355 nm pulses to match the in-beam structure of the linac for Spallation Neutron Source (micropulses that are 50 ps long, separated by 2.5 ns, gated into minipulses of 650 ns that repeat at 1.058 MHz, and are bunched into 1 ms macropulses).

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

(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 dimensions of approximately 6'x3"x3";
- no requirement for chilled water;
- a power supply remotely controllable through Ethernet cables; and
- radiation resistance for doses greater than 10^6 rads.

Based on previous experiments, the key components of a radiation-resistant laser system are the YAG crystal, the fold prism, a 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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17. 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—Electron microscopy and microcharacterization capabilities are important in the materials and biological sciences and are used in numerous research projects funded by the Department. Major advances are being sought for capability to characterize and understand materials, especially nanoscale particles, in their natural environment at high resolutions typical of electron microscopy and with good temporal resolution. To support this research, grant applications are sought to develop stages and holders that provide a suitable environment and also incorporate means to measure material behavior at the same time; electron sources and detectors that will provide more signal and better temporal resolution; and systems that automate simultaneous data collection, analysis, quantification, and feedback:

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 reach 80 Torr or higher during operation, and apply or measure at least two separate signals, such as current and voltage, at the same time. Proposed solutions must also be compatible with analytical energy dispersive spectroscopy.

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.

Ultra-high efficiency spectrometers for analytical energy dispersive spectroscopy and/or electron energy loss spectroscopy. Approaches of interest should include efficient detector materials and improved geometry for maximum signal collection. Proposed solutions should also provide at least one additional integrated electron detector to allow parallel image and spectroscopic data acquisition without reorienting a sample. 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.

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

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; (3) heated probes combined with dynamic thermal measurements including thermomehcnical, temperature, and integrated with Raman and mass-spectrometry systems, and (4) probes integrated with electrical, thermal, and magnetic field sensors 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 and tuning-fork force detectors compatible with existing low-temperature high-magnetic field environments 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) interactive SPMs incorporating decision making process on the single-pixel level. 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, for energy research. Particularly of interest are (a) variable pressure environmental cells that can be adapted to existing instrumental platforms, and (b) environmental cells compatible with aperture and apertureless optical and microwave imaging, as well as imaging modalities providing local chemical information.

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

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18. 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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19. INSTRUMENTATION AND TOOLS FOR MATERIALS RESEARCH USING NEUTRON SCATTERING

As a unique and increasingly utilized research tool, neutron scattering makes invaluable contributions to the physical, chemical, and biological sciences. The Department of Energy supports neutron scattering and spectroscopy facilities at neutron sources where users conduct state-of-the-art materials research. Their experiments are enabled by the convergence of a range of instrumentation technologies. The Department of Energy is committed to enhancing the operation and instrumentation of its present and future neutron science facilities (References 1-3) so that their full potential is realized.

This topic seeks to develop advanced instrumentation that will enhance materials research employing neutron scattering. 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 neutron 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 neutron scattering 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 neutron scattering facilities with links at: http://www.ncnr.nist.gov/nsources.html and http://www.ncnr.nist.gov/.

Grant Applications are sought in the following subtopics

a. Advanced Optical Components—Develop novel or improved optical components for use in neutron scattering instruments (References 4-6). Such components include, neutron choppers, neutron guides, neutron lenses and focusing mirrors, neutron monochromators, neutron polarization devices including ^{3}He polarizing filters, radio-frequency flippers, superconducting coils, and Meissner shields. Grant applications also are sought for novel uses of such components in neutron scattering instruments.

b. Advances Sample Environment—Develop instrumentation and techniques for advanced sample environment (Reference 7, 8) for neutron scattering studies, with an emphasis on controlled chemical and gaseous environment. These environment should simulate conditions relevant to energy-related materials and should provide a novel means of achieving extreme sample conditions of temperature, pressure, electric and magnetic fields (or combinations thereof).

c. Software Infrastructure—Development of user friendly software tools that enhance the utilization of the data produced by neutron and x-ray scattering and imaging instruments (References 2,3), thereby supporting the next generation of discovery science via data intensive, multi-technique experiments at multiple facilities. In particular, software is needed for the co-location of these data and to enable robust access by the experimental team, so that team members would have a user-friendly means of working with the data. Also of interest is advanced software tools for reduction, analysis, and simultaneous modeling of x-ray and neutron scattering data. The existing DOE ESnet infrastructure (http://www.es.net/) can be leveraged to support data movement, caching, and mirroring between DOE user facilities, thereby enabling collaborative scientific research among facility users, as well as novel combinations of experimental techniques.

Questions - contact Thiyaga P. Thiyagarajan (P.Thiyagarajan@science.doe.gov)

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20. NOVEL MEMBRANE AND ELECTRODE DEVELOPMENT FOR ADVANCED ELECTROCHEMICAL ENERGY STORAGE

The projected doubling of world energy consumption within the next 50 years, along with environmental and resource constraint concerns about using fossil fuels, have spurred great interest in generating electrical energy from renewable sources such as wind and solar. However, the variable and stochastic nature of renewable sources makes solar and wind power difficult to manage, especially at high levels of penetration. To effectively use the intermittent renewable energy and enable its delivery on demand, an electrical energy storage (EES) system will be required. For example, a storage system operating near an intermittent, renewable wind energy source can smooth out wind variability, lessen the slope on ramp rates, and, if of sufficient scale, store off-peak wind energy. EES also would be an effective tool to improve the reliability, stability, and efficiency of the future electrical grid, which is expected to support plug-in electrical vehicles and enable real-time, two-way communication to balance demand and supply. 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, and provide high levels of power quality, while increasing grid stability. Distributed energy storage near load centers can reduce congestion on both the distribution and transmission systems.

There exist a number of potential technologies for stationary electrical energy storage. Among the most promising are electrochemical energy storage technologies, such as batteries, that can efficiently store electricity in chemicals and reversibly release it according to demand. Early technologies, including lead-acid batteries and various nickel batteries, all shared the same cathode (nickel oxyhydroxide in the charged state). Some of the more recent technologies – including Li-ion, Na-beta, flow batteries, and lead-carbon batteries – have been demonstrated for utility applications. However, electrochemical energy storage technologies are facing challenges in meeting the performance and economic matrices for stationary applications. Therefore, both basic and applied research is required to further develop current technologies and to discover new technologies that can address the needs for renewable integration and grid applications.

Given that the performance of electrochemical storage devices closely relies on properties of materials to make cell components, this topic focuses on development of advanced materials or structures as electrodes and membranes for batteries. Of particular interest are the latest technologies such as flow batteries and some unique Li-ion technologies that are potentially suitable for the stationary applications. With this perspective in mind, grant applications are sought to develop novel electrodes and membranes for advanced electrochemical energy devices. **Grant applications are sought only in the following sub-topics**.

a. Cost Effective, Highly Selective Membranes for Redox Flow Batteries—Redox Flow Batteries (RFBs) store electrical energy in reduced and oxidized species contained in solution electrolytes that flow through positive and negative electrodes. Between the electrode compartments is a membrane that selectively allows cross-transport of non-active species (e.g., H^+, Na^+, etc.) to maintain electrical neutrality and electrolyte balance. As such, the energy and power can be decoupled and designed separately, making them attractive for high output applications, such as for transmission grid operations. For renewable and load leveling applications, the ability of RFBs to discharge energy for a duration of hours is an important advantage. Among the promising flow batteries are all-vanadium cells, zinc-bromide, sodium-polysulfide, etc. Although the redox chemistries often demonstrate an excellent electrochemical reversibility, a number of challenges – cost, limit of operation conditions, durability, etc. – must be overcome before broad market penetration can be achieved. In part, the high cost is attributed to the costly membrane, which also needs improvements in durability and selectivity. Grant applications are sought to develop a low cost, robust proton membrane that can demonstrate satisfactory properties for redox flow batteries, while being more cost-effective than the current technologies.

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

b. Novel Synthesis Approaches for Low Cost, Long Life Li-Ion Batteries—Li-ion batteries that store electrical energy in electrodes made of Li-intercalation (or insertion) compounds have been extensively investigated for hybrid and electrical vehicle applications that require high power and high energy densities, due to rigorous weight and volume constraints. In comparison, the cost, calendar life, and cycle life of the batteries are the most critical parameters for stationary applications. As such, the focus of this sub-topic is on Li-ion technologies that offer significant improvement in cycle life, calendar life, cost, and easy heat management.

Grant applications are sought to develop novel electrode materials and structures that enable "zero" strain Li-insertion without SEI layer formation, in order to improve battery performance and economy. One attractive approach would be to utilize composite materials or structures that combine desirable properties of different components and phases. However, traditional methods that rely on mechanical or chemical mixing have not been very effective in terms of cost and performance. Therefore, novel methods for the synthesis of novel composite electrode materials, such as from self-assembly, may greatly reduce manufacturing cost and improve performance.

Grant applications also are sought to develop nano-electrodes from cost-effective electrode materials, either known or new, for Li-ion batteries. Approaches of interest must demonstrate long cycle and calendar life, while being cost-effective for distributed stationary storage.

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

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21. HIGH PERFORMANCE MATERIALS FOR NUCLEAR APPLICATION

The Department of Energy is seeking to advance engineering materials for service in nuclear reactors. **Grant applications are sought only in the following subtopics:**

a. Specialty Steels—Grant applications are sought to develop radiation resistant steels, ferritic-martensitic (FM) steels, and Oxide Dispersion Strengthened (ODS) steels that can be used in liquid metal reactors at 400-750°C, have improved creep strength, and can be formed and welded. Grant applications also are sought to improve the weldability and formability of FM and ODS steels, develop methods to monitor i*n situ* irradiation performance in these materials, and develop improved non-destructive evaluation techniques.

Questions – contact Sue Lesica (sue.lesica@nuclear.energy.gov)

b. Refractory, Ceramic, Ceramic Composite, Graphitic, or Coated Materials—Grant applications are sought to develop refractory, ceramic, ceramic composite, graphitic, or coated materials that can be used in the Generation IV Advanced Gas Cooled Reactors Next Generation Nuclear Plant (NGNP) at temperatures above 900°C in a thermal neutron spectrum environment during normal operations and accidents. These ceramics, graphitic, or coated materials should have the following characteristics: (1) low thermal expansion coefficients, (2) excellent high-temperature strength, (3) excellent high-temperature creep resistance, (4) good thermal conductivity, (5) ability to endure a high-neutron-fluence environment, (6) ability to be easily fabricated, (7) capable of being joined, (8) low erosion properties in flowing helium, and (9) ability to survive air and/or water ingress accidents. Because high temperature strength and corrosion resistance may be difficult to achieve with a single material, composite or coated systems may be required.

In addition, grant applications are sought to develop methods for real-time *in situ* monitoring of the irradiation performance of these NGNP refractory, ceramic, graphitic, and coated composite materials. Approaches of interest include the development of sensors that can monitor the mechanical properties of these materials during their service lifetime and during large temperature changes.
Questions – contact Sue Lesica (sue.lesica@nuclear.energy.gov)

c. Assessment and Mitigation of Materials Degradation—Grant applications are sought to develop technologies for the assessment and mitigation of materials degradation in Light Water Reactor systems and components, in order to extend the service life of current light water reactors. Approaches of interest include (1) advanced *in situ* techniques for the monitoring of swelling in stainless steel, hardening of reactor pressure vessels, and the degradation of concrete; (2) new welding techniques for component repair; (3) methods that can mitigate or predict irradiation and aging effects in reactors and components, and (4) improved nuclear fuel cladding materials.

Questions – contact Sue Lesica (sue.lesica@nuclear.energy.gov)

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22. ADVANCED COAL RESEARCH

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon fuels. In supplying this energy need, however, 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) Conversion to Fuels & Chemicals—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 consumption of carbon-based energy worldwide, depletion of carbon-based energy resources, and low efficiency in current energy systems. Therefore, grant applications are sought to develop novel concepts, based on the use of advanced catalysts, for the conversion of CO_2 from energy production and utilization systems to value-added fuels and industrial chemicals. Proposed approaches must be novel and innovative, show clear economic advantages over the existing state of the art, and provide the data needed to demonstrate the CO_2 conversion, the projected economics, and the commercial feasibility.

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

b. Alternative Fuels: Catalytic Reaction Processing of Coal and Biomass in Ionic Liquids—The co-processing of coal and biomass is facilitated with ionic liquids, either as solvents for extraction or as reaction media with very good properties for catalyst solubilization. The scientific literature reports numerous chemical reactions in which ionic liquids are the media in which the reaction occurs. These reactions include cracking, dissolution, hydrogenation, dimerization, isomerization, oligomerization, and others. The ionic liquids used in a reaction or in catalytic systems are reported to show better activity, selectivity, and stability than traditional systems. They provide better yields, better and more controllable distribution of reaction products, and in some cases faster kinetics. Reactions in ionic liquids also occur at significantly lower temperatures and pressures than conventional reactions, resulting in lower energy costs and capital equipment costs. Ionic liquids can act as both catalyst and solvent. In many systems, the reaction products can be separated by simple liquid-liquid extraction, avoiding energy intensive and costly distillation.

Grant applications are sought for catalytic co-processing of coal and biomass or syngas in ionic liquids to produce value added fuels and industrial chemicals. Proposed approaches must be novel and innovative, show clear economic advantages over the existing state of the art, and provide the data needed to demonstrate the feedstock conversion, the projected economics, and the commercial feasibility.

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

c. Solid Oxide Fuel Cells: Analytical Tools for *In Situ* Electrocatalyst Research—It is well known that the properties (composition, crystallography, and electronic character) of Solid Oxide Fuel Cell (SOFC) electrocatalysts/surfaces play a direct role in determining the efficiency with which the reduction of O_2 occurs. Traditionally, these surface properties are determined through a combination of room-temperature analytical techniques, typically under ultra-high vacuum. It would clearly be advantageous to characterize electrocatalyst surface properties under *in situ* conditions (high-temperature, high-pressure, and polarization), in order to directly correlate them with electrocatalytic performance under normal operating conditions. Although synchrotron x-ray techniques are available to characterize the crystallography and surface chemistry of model thin-film electrocatalysts under *in situ* conditions, techniques for the *in situ* characterization of surface electronic character are notably absent. If such techniques were available, they could enable potential breakthroughs in many practical electrocatalysis applications.

Grant applications are sought for the development of equipment and techniques to enable such *in situ* experiments to characterize the surface electronics. *In situ* conditions are defined as at least 700°C, one atmosphere of air, and up to 1V polarization. For example, recent advances in Scanning Tunneling Microscopy (STM) suggest that it may be possible to collect information about the electronic character along with images of atomic resolution, at the temperatures and pressures of interest. However, considerable experimental difficulties exist when applying STM to the aforementioned *in situ* conditions; therefore, modifications to commercially-available equipment or new modes of use would be required to advance the state-of-the-art. The STM approach represents just one example; other approaches (not limited to STM) also are sought to develop or demonstrate techniques applicable to the stated *in situ* conditions.

Phase I should consist of designing components and initial experiments to establish feasibility. Phase II should focus on the development and optimization of promising designs from Phase I, with the ultimate demonstration of operating hardware.

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

d. Development of Air Capture of Carbon Dioxide—Capturing carbon dioxide (CO_2) directly from the atmosphere may have potential for reducing the effects of greenhouse gases on climate change. A primary challenge of such a scheme is the very low concentration of CO_2 in air (0.04%), which causes large scale capture to be energy intensive. By contrast, the flue gas from power plants that burn fossil fuels contains a much higher concentration of CO_2 (typically 10-15%); therefore, scrubbing CO_2 from flue gas is more economical. Nonetheless, it is widely believed that the mitigation of climate change will require the simultaneous employment of air capturing schemes along with flue gas scrubbing. A successful scheme for capturing CO_2 from air would offer several unique advantages, including the ability to locate the device in close proximity to a remote subterranean storage site, and the potential not only to stabilize CO_2 emissions but also to reduce atmospheric CO_2 concentrations.

Therefore, grant applications are sought for innovative and cost effective approaches to the removal of CO_2 from air. Proposed approaches must include (1) an air capture demonstration that represents an advancement in existing air capture technology; (2) a viable plan for an increase to commercial scale based on the demonstrated technology, including an assessment of the projected cost per ton of CO_2 captured; (3) a design that will produce overall negative CO_2 emissions with consideration to power drawn by the device, including an appropriate analysis; and (4) a recommendation for at least one candidate site for viable commercial scale testing of an air capture device.

Questions – contact David Hopkinson (david.hopkinson@hq.doe.gov)

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Subtopic a - Novel Sequestration Concepts - Carbon Dioxide (CO_2) Conversion to Fuels & Chemicals

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23. FOSSIL ENERGY ADVANCED RESEARCH

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 Advanced Research (AR) program within the National Energy Technology Laboratory's Office of Coal and Power Systems fosters the development of innovative, cost-effective technologies for improving the efficiency and environmental performance of advanced coal and power systems. The AR program seeks to bridge the gap between fundamental research into technology alternatives and applied research aimed at scale-up, deployment, and commercialization of the most promising technologies. The AR program encompasses three major subprograms:

- **Sensors and Controls.** The implementation of sensors and advanced controls in power systems can improve operational efficiency, reduce emissions, and lower operating costs. These sensors and controls must provide reliable and consistent data, longevity of use, and ease of calibration. However, it has been a challenge to develop sensors and controls that are able to endure the harsh environments associated with advanced power systems. This environment includes high temperatures (800-1500°C), high pressures (500-1000 psi), and corrosion due to abrasive materials.

- **High Performance Materials** research cuts across many scientific and technological disciplines to address materials requirements for all fossil energy systems, including innovative advanced power systems. The goal is to bridge the gap between basic and applied research, often by pursuing "breakthrough" concepts to develop materials with unique thermal, chemical, and mechanical capabilities.

Computational Energy Sciences research is pursued to simulate the complex processes occurring inside a coal gasifier, or across an entire chemical or power plant. These applications are made possible by today's supercomputers and advanced simulation software, helping scientists and engineers to better understand the fundamental steps in a complex process so they can optimize the design of the equipment needed to run it. The speed and flexibility of these computational tools are crucial in the development of commercial scale simulations.

Grant applications are sought only in the following subtopics:

a. Development of Gas Composition Sensor System for Use on Full Scale Power Generation Systems—The high-temperature harsh environment of advanced power systems (combustion, gasification, fuel cells, gas turbines) requires several types of on-line continuous measurements to be made in order to operate and control the system efficiently. These harsh environments include a temperature range of 500^{o}C-1600^{o}C, a pressure range of 300-700 psi, and the presence of constituents that result in corrosive and erosive conditions. Applications may include a coal gasification system, which is a highly reducing environment or an oxygen enriched combustion environment (e.g., oxy-fired combustion, oxygen enriched combustion turbines), which is a highly oxidizing type environment.

Current on-line techniques typically measure one or two gas species, usually in an exhaust or stack effluent. This topic seeks to expand the sensor capability so that multiple gases can be detected and quantified in harsh environments. 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.

Therefore, grant applications are sought for the development of a fully integrated gas composition sensor that can quantify multiple gas species common to fossil energy systems. Specific measurements of interest include quantification of the gas composition (e.g. H_2, CO, CO_2, O_2, H_2O, CH_4, NOx, H_2S, SO_2, SO_3, trace contaminants, etc), so that the measurements can be made on-line and in a continuous/semi-continuous manner. Sensor types of particular interest include high temperature micro-sensors, laser-based sensors, fiber optics, or other novel approaches. Grant applications must (1) present a comprehensive approach that includes packaging and full integration with data collection devices, and (2) consider design features for installation on a full-scale power generation facility, in order to enable on-line continuous/semi-continuous measurements of the gas composition. Proposed approaches that require extractive sampling followed by laboratory analysis, or techniques that require delivery of the sample to a remotely located analyzer, are not of interest and will be declined.

Questions: Contact Norm Popkie (norman.popkie@netl.doe.gov)

b. Advanced Concepts for Powering Wireless Sensors—Within a large scale power generation facility, there are several opportunities to make use of waste heat, vibration, and other forms of "lost" energy that could serve to benefit the overall performance of the system. Grant applications are sought to develop advanced concepts for utilizing this "lost" energy to remotely power wireless sensors, thereby replacing or supplementing existing battery systems. Proposed approaches must (1) be able to reliably harvest and store energy from the local service environment without connection to a centralized power source and without a requirement for recharging; (2) provide the wireless sensor with reliable and on-demand voltage; (3) be robust enough for long-term service life in a power plant environment; and (4) operate at near-ambient temperatures and have good functionality at temperatures in excess of 200° C.

Grant applications should address (1) the viability and/or limitations of current state-of-the-art systems for powering wireless sensors, as well as systems currently under development, and (2) the manufacturability, cost, and long-term viability of the candidate system under realistic operating conditions.

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

c. Computer-Aided Development of Novel New Materials for Energy Conversion from Coal—Novel materials that can withstand high temperatures and extreme environments are needed for the development of efficient energy systems. Basic requirements include 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 high performance computing to guide experiments. This synergy between experiment and advanced materials modeling should significantly enhance the synthesis of novel high-temperature materials. In particular, computer simulations to study the structure, properties, and processing of materials on the atomic scale are needed to replace traditional trial-and-error experimental methods, which are costly and time-consuming. A wide range of computer modeling tools – e.g., highly accurate quantum mechanics (electronic structure) methods, simple interatomic potentials, and databases to support the models – could be brought to bear on addressing critical materials needs. Therefore, 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.

Step improvements in the performance of existing materials are not the goal of this subtopic; rather, the focus is on the development of new materials with high performance potential, especially materials that previously have not been considered or identified for fossil energy applications. Materials of interest include alloys based on refractory metal elements – such as W, Nb, Mo, and Cr – which are emerging as a potential solution for this challenging application. Approaches of interest should address reliability of performance, ease of fabrication, and affordability, which are key viability indicators for these new material concepts.

Questions: Contact Richard Dunst (dunst@netl.doe.gov)

d. Central Processing Unit (CPU) and Graphical Processing Unit (GPU) Parallel Development of an Eulerian-Lagrangian Multiphase Model—Multiphase science-based computer simulations will play a significant role in the design, operation, and troubleshooting of multiphase flow devices in fossil fuel processing plants. Eulerian-Lagrangian models, which treat the gas/liquid phase as a continuum or Eulerian field and the solids as discrete Lagrangian computational particles, have shown tremendous computational speeds compared to traditional Eulerian-Eulerian or Two Fluid Models. In fact, an Eulerian-Lagrangian model running in serial on a single core of a desktop machine compares favorably to an Eulerian-Eulerian model running in parallel across many CPUs. Furthermore, these speeds generally are achieved without sacrificing fidelity. When applied to the simulations of industrial-scale problems concerned reacting gas-solids or liquid-solids processes, the computational speeds provided by an Eulerian-Lagrangian model can enable solutions to be achieved within a reasonable time. These computer-based simulations can aid in the design, optimization, and scale-up of industrial processes.

Grant applications are sought to further increase the computational speed of parallel Eulerian-Lagrangian models that implement multiple CPUs, each running in conjunction with multiple graphical processor units (GPU's). The ultimate goal is the development of an Eulerian-Lagangian model that could run orders of magnitude faster than current state-of-the-art Eulerian-Eulerian parallel models, while still maintaining a high degree of fidelity.

Questions: Contact Steven Seachman (Steven.Seachman@netl.doe.gov

e. Development and Demonstration of Advanced Process Engineering Co-Simulator (APECS) Process/Computational Fluid Dynamics (CFD) Co-Simulations for Advanced Energy Systems—The Advanced Process Engineering Co-Simulator (APECS) is a unique process/equipment co-simulation software system that provides capabilities for the design and optimization of overall power plant performance by accounting for complex thermal and fluid flow phenomena in individual equipment items. APECS software, which uses high-fidelity computational fluid dynamics (CFD) models, is built on (1) the integrated access, workflow, and data services of the ANSYS® Engineering Knowledge Manager™; and (2) the process industry standard CAPE-OPEN (CO), which provides plug-and-play model interoperability. The commercial CFD code, FLUENT®, is available for use in APECS as a CO-compliant unit operation model. Using APECS, engineers can effectively and efficiently integrate, solve, and analyze co-simulations by combining FLUENT® CFD models with CO-compliant steady-state process simulators such as Aspen Plus®.

Grant applications are sought to develop process/equipment co-simulations for advanced coal-fired energy systems with carbon capture. Successful applicants will focus on using APECS to integrate FLUENT® CFD models into Aspen Plus® power plant simulations. It is strongly preferred that applicants make use of pre-existing FLUENT CFD models and not develop new CFD models as part of the proposed work. The Aspen Plus simulations may be developed as part of the proposed work or made available by NETL. Successful applicants also will provide a clear and concise plan for demonstrating the benefits of using their process/equipment co-simulations to help develop high-efficiency, near-zero-emission fossil energy systems.

Questions: Contact Sara Zenner (sara.zenner@netl.doe.gov)

REFERENCES :

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

1. 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 - New Approach to Process Control Architecture for Operation of Large Scale Central Power Systems

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

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

1. Kwai S. Chan and David L. Davidson. "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) (Full text is available at: http://cat.inist.fr/?aModele=afficheN&cpsidt=15214545)

2. Giovanni Garberoglio, Anastasios I. Skoulidas and J. Karl Johnson. "Adsorption of Gases in Metal Organic Materials: Comparisons of Simulations and Experiments", Journal of Physical Chemistry B, 109(27), pp. 13094-13103, June 2005. (ISSN: 1089-5647) (Full text available at: http://pubs.acs.org/doi/abs/10.1021/jp050948l?prevSearch=&searchHistoryKey)

Subtopic e - Computational Model Development and Optimization for Multiphase Flow Systems

1. "APECS (Advanced Process Engineering Co-Simulator", Advanced Research: Computational Energy Sciences, NETL. (URL: http://www.netl.doe.gov/technologies/coalpower/advresearch/apecs.html)

2. "5 Technology Roadmap". (Full text at: http://www.netl.doe.gov/publications/proceedings/09/mfs/2006TechnologyRoadmap.pdf)

3. For background information on this topic and the technology behind the APECS co-simulation software, please reference the following link: http://www.netl.doe.gov/onsite_research/Facilities/apecs.html

4. M.J. Andrews and P.J. O'Rourke. "The Multiphase Particle-in-Cell (MP-PIC) Method for Dense Particle Flows", International Journal of Mulitphase Flow, Vol. 22, Issue 2, pp. 379-402, (1996). (ISSN: 0301-9322) (Full text available at: http://www.elsevier.com/wps/find/journaldescription.cws_home/234/description#description

5. D.M. Snider. "An Incompressible Three Dimensional Multiphase Particle-in-Cell Model for Dense Particle Flows", Journal of Computational Physics, 170, Issue 2, pp. 523-549, (2001). (ISSN: 0021-9991) (Full text available at: http://www.elsevier.com/wps/find/journaldescription.cws_home/622866/description#description)

24. CLIMATE CONTROL TECHNOLOGY FOR FOSSIL ENERGY APPLICATION

This topic addresses carbon dioxide (CO_2) emissions and its management for climate control. Starting with the industrial age, the combustion of carbon-based fossil fuels has raised global emissions of CO_2 compared to levels two centuries ago. A large body of scientific evidence points to the recent build-up of CO_2 and other greenhouse gases (GHG) in the atmosphere worldwide as a contributing factor to global warming. This build-up could lead to future significant global climate imbalances and adverse consequences for human health and welfare. Strategies to reduce GHG include CO_2 capture from large stationary industrial emitters; geologic storage of CO_2; and the reuse of CO_2 for chemical, manufacturing, petroleum, and other applications. Significant research is currently being pursued for new technologies that will advance implementation of carbon capture and sequestration (CCS) technologies, along with alternative uses of CO_2 for industrial applications. **Grant applications are sought only in the following subtopics:**

a. Advanced Membranes for CO_2 Capture from Existing Coal-fired Power Plants—In membrane-based capture, permeable or semi-permeable materials selectively transport/separate of CO_2 from flue gas. Grant applications are sought to develop advanced membrane technology to overcome the key challenges to the use of membranes for capturing CO_2 from existing coal-fired power plant flue gas. These challenges include: (1) large flue gas volume; (2) relatively low CO_2 concentration (less than 15% by volume); (3) low flue gas pressure (i.e., the driving force); (4) the presence of flue gas contaminants (e.g., SO_2, trace elements, uncollected fly ash); and (5) the need for membranes with high surface area.

In responding to this subtopic, applicants must demonstrate a thorough understanding of the technology being proposed. In particular, grant applications must describe the current level of performance of the proposed technology relative to both CO_2 capture removal efficiency and cost, and the approach to be followed to meet the DOE performance goal. This description should include all auxiliary power required – such as blowers, compressors, and/or pumps – and all annual operating costs associated with the technology. Additionally, the applicant must provide information describing the membrane transport mechanism, membrane permeability (in gpu) and selectivity under realistic operating conditions, any anticipated effects of aging, the anticipated effect of flue gas contaminants and water on membrane performance, the mechanical stability of the membrane, the estimated membrane cost (in $/m2), the estimated membrane size (in m2/ton CO_2 captured), and the expected operating conditions of the membrane system (temperature, pressure, pressure drop, etc). Finally, since this subtopic deals with CO_2 capture from an existing coal-fired power plant, applicants should include a block flow diagram that describes how the proposed technology would be retrofitted to a typical pulverized coal fired power plant. This diagram should include the relationship of the membrane capture system with respect to the coal-fired boiler and any associated (or required) pollution cleanup systems.

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 to capture CO_2 from flue gas through chemical absorption, physical adsorption, or a combination of the two effects. Possible configurations for contacting the flue gas with the solid particles include fixed, moving, and fluidized beds. Grant applications are sought to develop sorbent based systems for capturing CO_2 from existing coal-fired power plants. Solid sorbents used for flue gas CO_2 capture must be capable of having high CO_2 loading capacities while being able to maintain particle performance in the presence of flue gas contaminants. The applicant should provide information relevant to overcoming the following technical challenges: (1) large flue gas volume; (2) relatively low CO_2 concentration; (3) flue gas contaminants; and (4) high parasitic power demand for sorbent recovery.

In responding to this subtopic applicants should demonstrate a thorough understanding of the technology being proposed. In particular, grant applications must describe the auxiliary power required, the proposed configuration for contacting the flue gas with the sorbent, the CO_2 working capacity (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) and theoretical maximum capacity (in mol CO_2/kg sorbent), any anticipated effects of flue gas contaminants, chemical reactions for the CO_2 adsorption/regeneration cycle, heats-of-adsorption data for adsorption/desorption reactions, the effects of water vapor in the adsorption reaction, the estimated sorbent cost (in $/kg sorbent) if manufactured in large quantities, the expected performance of the sorbent in terms of attrition or blinding, the sorbent particle size and surface area, and the concentration of the active component. Since this subtopic deals with capture from an existing coal-fired power plant, applicants should include a block flow diagram of how their technology would be retrofitted to a typical pulverized coal fired power plant. This diagram should include the relationship of the sorbent capture system with respect to the coal-fired boiler and any associated (or required) pollution cleanup systems.

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

c. Characterization of CO_2 Geologic Repositories—Advancements are needed for the high resolution characterization of CO_2 reservoirs, cap rock, and bounding strata to insure integrity and permanence of storage, and to identify potential leakage pathways. In particular, grant applications are sought to identify and characterize, with high resolution, (1) key stratigraphic properties that include, but are not limited to, lateral continuity, thickness, depth, intra-formational heterogeneities, structural attitude, and facies changes for both the reservoir and cap rock; (2) reservoir and cap rock discontinuities that could affect CO_2 migration out of the reservoir, such as open fractures and faults; and (3) reservoir conditions that could affect CO_2 injectivity and capacity, including, but not limited to, porosity, permeability, pressure, temperature, and water chemistry formation and flow. Typical reservoirs are composed of sedimentary strata at 760 meters depth or greater. Examples of reservoirs include sandstone and fractured carbonates. Examples of cap rock, which serve as seals, include mudstones and evaporites.

Approaches of interest include, but are not limited to, efficient, cost-effective advancements in geophysical, geochemical, geomechanical, wellbore, hydrologic, and petrophysical techniques. Multidisciplinary, integrative approaches are encouraged. Proposed measurements should be repeatable to enable time-lapse analyses between baseline measurements and subsequent surveys. Data acquisition methods of interest include surface, borehole, surface-to-borehole, crosshole, and aerial/satellite techniques. Advancements in data acquisition approaches that would reduce cost, time, or are noninvasive are especially encouraged. Grant applications that propose technologies that duplicate available commercial technologies or are minor enhancements to commercial technologies will be declined.

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

d. Monitoring of CO_2 Geologic Storage—Large quantities of injected CO_2, ranging from 1-2 or more million metric tonnes per year, are planned for a single storage site. As supercritical CO_2 is injected into a reservoir for sequestration, a buoyant plume can rise within the reservoir, become trapped in pore space, become dissolved in brine, and be incorporated or adsorbed onto minerals. Reliable and cost-effective monitoring, verification, and accounting (MVA) of the CO_2 in these locations will be an important part of implementing CCS. The MVA process includes tracking the location of the injected CO_2 plume, ensuring that the injected CO_2 is not leaking, and verifying the quantity of CO_2 that has been injected underground. Grant applications are sought to (1) monitor spatial-temporal distribution of the injected CO_2 over the life cycle of CCS operations and post-injection; (2) quantify the amount of CO_2 permanently residing within a target formation as well as mechanism for storage; and (3) identify and quantify the CO_2 that has migrated from the reservoir into bounding strata, overlying aquifers, or the atmosphere.

The monitoring approaches of interest include, but are not limited to, efficient, cost-effective advancements in geophysical, geochemical, geomechanical, wellbore, hydrologic, and petrophysical techniques. Multidisciplinary, integrative approaches are encouraged. Proposed measurements should be repeatable to enable time-lapse analyses between baseline measurements and subsequent surveys. Data acquisition methods include surface, borehole, surface-to-borehole, crosshole, and aerial/satellite techniques. Advancements in data acquisition approaches that would reduce cost, time, or are noninvasive are especially encouraged. Grant applications that propose technologies that duplicate available commercial technologies or are minor enhancements to commercial technologies will be declined.

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

e. Performance of CO_2 Storage—Performance of CCS operations includes a measure of the safe and permanent storage of CO_2 injected into a reservoir. Performance and risk assessment of existing CO_2 storage operations entail a number of risks, which include, but are not limited to, wellbore leakage; leakage through natural cap rock discontinuities, such as open faults, fractures, and high permeability zones; damage to the reservoir caused by operations, including overpressurization that results in leakage; migration of CO_2 into overlying USDW (Underground Sources of Drinking Water), which affects water quality; ground deformation, such as surface uplift or settlement; and induced seismicity. Technologies are needed to prevent and mitigate these risks to CO_2 geologic storage of CO_2. Therefore, grant applications are sought for advanced, innovative technologies that will prevent or mitigate the following risks: (1) wellbore leakage; and (2) leakage through damaged reservoirs or through natural cap rock discontinuities such as open faults, fractures, or high permeability zones.

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. Grant applications that advance injection well completion design or the development of materials to ensure that well integrity is maintained are encouraged. Proposed technologies should take advantage of the knowledge-base that has been developed for mitigating leakage: R&D projects involving natural gas storage, underground disposal of liquid waste products, and groundwater and soil contamination all may be applicable to CO_2 storage. Applications that propose technologies that duplicate available commercial technologies or are minor enhancements to commercial technologies will be declined.

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

f. 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. Therefore, grant applications are sought to develop pathways and novel approaches for the beneficial use of CO_2, in order to mitigate emissions in areas where geologic storage may not be an optimal solution. Approaches of interest include the development of technologies or novel methods to (1) integrate power production with fossil fuels to convert captured CO_2 to fuels and marketable chemicals or products; (2) use CO_2 from an effluent stream to produce stable solid materials that are either useful products with economic value or a low cost produced material; (3) react CO_2 with industrial chemical waste streams to produce useful products; and (4) react CO_2 with the metallic ions in saline water to form less-soluble carbonates that can be removed. Because the use of algae is addressed in other program areas, it is not of interest for this subtopic, and grant applications that propose the use of algae will be declined.

Questions - contact Darin Damiani (Darin.Damiani@netl.doe.gov)

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Subtopic a - Advanced Membranes for CO_2 Capture from Existing Coal-fired Power Plants

1. "Carbon Capture R&D Program for Existing Coal-Fired Power Plants", U.S. DOE National Energy Technology Laboratory (NETL), DOE/NETL- 2009/1356, Feb. 2009. (Full-text available at: http://www.netl.doe.gov/technologies/coalpower/ewr/co2/pubs/EPEC%20CO2%20capture%20program%20overview%20feb09.pdf)

2. U.S. DOE NETL Existing Plants, Emissions and Capture –CO_2 Emissions Control Web page. (URL: http://www.netl.doe.gov/technologies/coalpower/ewr/co2/index.html)

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

1. "Carbon Capture R&D Program for Existing Coal-Fired Power Plants", U.S. DOE National Energy Technology Laboratory (NETL), DOE/NETL- 2009/1356, Feb. 2009. (Full-text available at: http://www.netl.doe.gov/technologies/coalpower/ewr/co2/pubs/EPEC%20CO2%20capture%20program%20overview%20feb09.pdf)

2. U.S. DOE NETL Existing Plants, Emissions and Capture –CO_2 Emissions Control Web page. (URL: http://www.netl.doe.gov/technologies/coalpower/ewr/co2/index.html)

Subtopic c - Characterization of CO_2 Geologic Repositories

1. "Carbon Sequestration Technology Roadmap and Program Plan 2007", U.S. DOE National Energy Technology Laboratory (NETL), May 2007. (Full text at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/project%20portfolio/2007/2007Roadmap.pdf)

2. "Carbon Sequestration Atlas of the United States and Canada", 2nd Edition, U.S. DOE National Energy Technology Laboratory, (2008). (Full text at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasII/atlasII.pdf)

3. "Monitoring, Verification, and Accounting of CO_2 Stored in Deep Geologic Formations", National Energy Technology Laboratory, DOE/NETL-311/081508, Jan. 2009. (Full text at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/MVA_Document.pdf)

4. "Carbon Dioxide Capture and Storage", Intergovernmental Panel on Climate Change (IPCC) Special Report, Cambridge University Press, (2005). (Full-text available at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports_carbon_dioxide.htm)

Subtopic d - Monitoring of CO_2 Geologic Storage

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. "Best Practices for: Monitoring, Verification, and Accounting of CO_2 Stored in Deep Geologic Formations", National Energy Technology Laboratory, DOE/NETL-311/081508, (2008). (Full-text at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/MVA_Document.pdf)

3. "Carbon Dioxide Capture and Storage", Intergovernmental Panel on Climate Change (IPCC) Special Report, Cambridge University Press, (2005). (Full-text available at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports_carbon_dioxide.htm)

Subtopic e - Performance of CO_2 Storage

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. "Monitoring, Verification, and Accounting of CO_2 Stored in Deep Geologic Formations", National Energy Technology Laboratory, DOE/NETL-311/081508, Jan. 2009. (Full text at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/MVA_Document.pdf)

3. "Remediation of Leakage from CO_2 Storage Formations", IEA Greenhouse Gas R&D Programme (IEA GHG), 2007/11, Sept. 2007. (Available by request to IEA at URL: http://www.ieagreen.org.uk/2007.html)

4. "Safe Storage of CO2: Experience from the Natural Gas Storage Industry", IEA Greenhouse Gas R&D Programme (IEA GHG), 2006/2, Jan. 2006. (Available by request to IEA at URL: http://www.ieagreen.org.uk/2006.html)

5. "Carbon Dioxide Capture and Storage", Intergovernmental Panel on Climate Change (IPCC) Special Report, Cambridge University Press, (2005). (Full-text available at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports_carbon_dioxide.htm)

Subtopic f - 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. "Carbon Dioxide Capture and Storage: Chapter 7 – Mineral Carbonation and Industrial Uses of Carbon Dioxide", Intergovernmental Panel on Climate Change (IPCC) Special Report, Cambridge University Press, pp. 319-337, (2005). (Full text available at: http://www.ipcc.ch/publications_and_data/publications_and_data_reports_carbon_dioxide.htm)

25. COAL GASIFICATION TECHNOLOGIES

Coal gasification produces synthesis gas (primarily a mixture of H_2 and CO), which can be converted into electricity, hydrogen, substitute natural gas, and other clean fuels, as well as high-value chemicals to meet specific market needs. Furthermore, while other sources of power may fluctuate, gasification systems operate on the low-cost, widely available, domestic feedstock of coal, and can be run on coal-biomass mixtures. By using coal to make hydrogen or methane, coal can be converted into clean fuels, with a much smaller carbon footprint than typical for coal combustion. For instance, a power plant run on clean hydrogen will only produce water as the flue gas.

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

a. 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, creates an incentive for developing a low-cost replacement. 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., greater than 15 vol%) in the syngas. Such gasifier products would have a unique opportunity for coupling with solid oxide fuel cells: the endothermic steam-methane reforming reaction would facilitate temperature control of the fuel cell and increase the thermal efficiency of the overall process.

Grant applications are sought to develop gasification concepts that produce high concentrations of methane in the gasifier, with coal as the predominate feedstock. While the primary gasification feedstock must be coal, feedstock mixtures of coal with biomass, petcoke, etc. will be considered (e.g., mixtures with 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 moisture content (dry vs. wet slurry); (3) coal rank; (4) solids residence time; (5) size of the reaction chamber; (6) feed rates of oxidant or steam; (7) particle sizes; (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 15 vol%. For pipeline applications, the gasifier should maximize the conversion to methane (subject to the limitations of thermodynamics, etc.).

Applications should include a simplified process flow diagram indicating, at a minimum, the anticipated temperature, pressure, and stream compositions for all streams entering and leaving the proposed concept. The Phase I work plan should describe the size of experiments in terms of planned quantities of material to be processed (e.g., grams of coal, gas flow rates), the size of the equipment to be utilized (e.g., reactor dimensions), and planned test temperatures and pressures. Additionally, experiments should be designed to analyze the methane content of produced syngas.

Because the syngas produced in these gasifiers may be targeted for a substitute natural gas product, 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. Also, processes other than gasification that produce syngas as a product/byproduct, such as steel-making or liquid fuel reforming, are outside the scope of this topic. Additionally, literature reviews will not be funded.

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

b. 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 result in thermal efficiency losses, a problem that is exacerbated with low rank coals that already have a high water content. On the other hand, dry feed gasifiers require extensive drying of the coal to ensure proper operations of the feed system, which also results in an energy penalty. Moreover, dry feed systems for coal gasification typically incorporate lock-hoppers, which are expensive and unreliable: lock-hopper systems utilize inert gas to pressurize the vessels, which adds diluent to the gasifier and operational costs to the gasification process. For dry feeding, the elevated operating pressure of the gasifier (in excess of 500 psig) makes solids feeding difficult – the solids (particularly high-moisture feedstocks) often bridge/clog the vessels. Finally, the DOE is interested in mixing coal with biomass as a way to reduce the carbon footprint of gasification-based applications, without the cost associated with capturing CO_2.

Grant applications are sought to develop systems, which do not include lock-hoppers, for reliably feeding coal-biomass mixtures into a gasifier operating at up to 1,000 psig. Proposed approaches must specify the feed characteristics of both the coal and the biomass, the feed device, and the target gasifier. Gasifier types are restricted to either entrained or transport. The coal-biomass mixtures must be 20% to 50% biomass. The grant application must include any processing/preparation of the feed – coal and/or biomass – prior to use by the feed system, and a preliminary analysis showing why this cost is expected to be a reasonable expense. (For example, the cost of biomass beneficiation could be more than offset by a reduction in the cost of transportation, or the cost of coal drying could be more than offset by increased gasifier efficiency.) A detailed study for optimizing the feed characteristics for the feed system and target gasifier must be part of the proposed project.

Although the proposed feed system does not have to be applicable for all kinds of coal or biomass, preference will be given to proposed feed systems that apply to economically significant and credible combinations, which account for availability and geographical proximity. Of particular interest are feed systems for minimally-dried low rank coal. Feed systems designed to target the transport gasifier must be able to handle feed with the following characteristics: (1) for coal, particle sizes of 500 micron average diameter, with no particles larger than 4,000 microns and less than 5% between 1,100 and 4,000 microns (fines are not a problem); (2) for biomass, particle size ~ 1mm average diameter.

Questions: Contact Jenny Tennant (jenny.tennant@netl.doe.gov)

c. High Temperature Heat Recovery IGCC—NETL's Clean Coal Technology program included two IGCC projects, one at the Polk Power Station operated by Tampa Electric Company (TEC) and one at the Wabash River Coal Gasification Repowering Project operated by Wabash River Energy Ltd. Both facilities experienced similar operational problems associated with their high-temperature heat recovery units (HTHRU). In addition, both facilities experienced significant down time as a result of erosion, corrosion, fouling, and pluggage of the HTHRU:

- At the Wabash IGCC facility, hot syngas from the gasifier flows to the HTHRU to produce high-pressure steam. The HTHRU is a vertical firetube steam generator that is used as a syngas cooler. It has hot syngas on the tube side. The syngas is cooled from 1,900 F to about 700 F in the HTHRU, generating 1,600 psia steam [1]. Steam from the HTHRU is superheated by the gas turbine heat recovery system for power generation. Ash deposits have occurred in the HTHRU and have created operational difficulties and caused high system pressure drops [2]. Removal of ash deposits required significant down time. The situation was further exacerbated by material spalling from the ash deposits and then lodging in the boiler tubes, plugging them and further increasing downtime due to the time required to remove the plugs. The rate and extent of ash deposition in the syngas cooler is a function of operational conditions, and is "proportional to the number of thermal cycles (full or partial load trips) experienced in the system" [1]. As the operators gained experience with the gasifier, improved reliability occurred, thereby decreasing the number of thermal cycles and decreasing the rate of ash deposition.

- At the Polk Power Station, hot syngas leaves the gasifier and passes through a radiant syngas cooler (RSC). The RSC had a design exit temperature of about 1350 F, but, due to the fact that it was oversized, the actual exit temperature was around 1050 F [3,4]. The syngas then enters the convective syngas cooler (CSC) flowing at high velocity to increase the heat transfer coefficient. Boiler feed water circulates through the CSC on the shell side by natural convection, generating 1650 psia steam [4]. The syngas leaves the CSC at a temperature between 700 and 750 F. The CSC has been the source of a variety of operational problems at Polk, caused by ash deposits that form in the CSC. In addition to plugging problems, these deposits can cause leaks to occur by deflecting the particulate-loaded syngas flow, resulting in tube metal loss via erosion. The CSC, which consists of six heat exchangers with associated interconnecting piping (each one a fire-tube shell and tube heat exchange) resulted in 478 unplanned outage hours, more than any other equipment at the station.

Grant applications are sought for novel ideas and approaches that can significantly reduce or even eliminate these problems, without adversely affecting the thermal performance of the system.

Questions – contact Ronald Breault (Ronald.Breault@netl.doe.gov)

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26. TECHNOLOGIES FOR CLEAN FUELS AND HYDROGEN FROM COAL

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

a. Concepts for Novel, Non-Precious-Metal-Based Processes or Membranes for Recovering Hydrogen from Coal—Hydrogen separation technologies have historically utilized precious Group VB and VIIIB metals, employed either as standalone membranes, alloys, or coatings on highly permeable substrates. The platinum group metals (PGM) – platinum, palladium, rhodium, ruthenium, iridium and osmium – occur in nature in close association with one another, as well as with nickel and copper. Platinum and palladium are found in the largest quantities in most PGM ores, while rhodium, ruthenium, iridium and osmium are produced only as co-products. Currently, fewer than ten significant PGM mining companies are operating worldwide, with declining production over the past 10 years. With the limited global diversity of resources and production capabilities, the supply of these precious metals can be unduly influenced, thereby restraining the ability to deliver centrally produced hydrogen with membrane separation technologies.

Therefore, grant applications are sought for laboratory-level research leading to the development of innovative non-precious metal membrane materials, concepts, and strategies for the separation of hydrogen from a coal-derived syngas. The successful membrane-based R&D project will be cognizant of the NETL Test Protocol for Testing of Hydrogen Separation Membranes, which defines appropriate temperature and pressure test conditions, as well as a series of suitable simulated syngas compositions that are recommended for demonstrating membrane viability. In addition to membrane processes, grant applications also are sought for other non-precious-metals-based technology concepts and strategies for producing hydrogen from coal or coal-based processes – routes for hydrogen extraction from any process streams or waste stream in a coal-based process will be considered. Approaches of interest should obtain 99.99% pure hydrogen, either from the development of an entirely new coal-based process, or from the development of a novel component for improving a known technology (e.g., a novel sorbent or process/reactor configuration for pressure swing absorption).

Experiments for new membrane embodiments should be designed to demonstrate progress towards meeting the DOE 2015 program goals for membrane flux (300 $SCFH/ft^2$ at a differential hydrogen partial pressure of 100 psi), purity (99.99% H_2), cost (less than $\$100/ft^2$ of membrane area), temperature (250 to 500ºC), chemical robustness (greater than 100ppm S tolerance and CO tolerant) and mechanical robustness (system operating pressure of 800 to 1000 psi), without the use of PGMs. Experiments conducted during Phase I should be designed to show progress toward meeting a DOE 2016 target for Central Hydrogen Production: reducing the cost of hydrogen by 25 percent compared to current coal-based technology.

For the application to be considered responsive, the applicant should describe how the proposed concept has potential to improve either process cost or efficiency. Also, the gas compositions utilized should be representative of a gas mixture that would be seen in a commercial coal gasification facility. Temperature, pressures and feed compositions of experiments should be justified in terms of being relevant for integrating the concept within a coal-based process. Studies that utilize inert or simple (e.g., single or binary) gas mixtures for lengthy testing are not sought. Finally, literature reviews, as well as concepts for natural gas reforming and water electrolysis, are not within the scope of this subtopic and will be declined.

Questions—Contact Robie Lewis (Robie.Lewis@netl.doe.gov)

b. Concepts for Enhanced Catalysts for Water-Gas-Shift and Fischer-Tropsch Processes for Gases from Co-Mingled Coal and Biomass Gasification—Recent systems studies have shown that the addition of biomass to a coal gasification feedstock would be beneficial. This process, known as the Coal-Biomass-to-Liquids (CBTL) process employs domestic coal and biomass feedstocks, has a better greenhouse gas footprint than conventional processes for petroleum fuels, and is projected to be economically competitive at a world oil price significantly below $100 per barrel. Improvements to several plant unit operations offer particular opportunities. For example, the use of water-gas shift (WGS) and Fischer-Tropsch (FT) technologies are well-known for converting syngas to high hydrogen content liquids. However, the current commercial catalysts used in WGS processes and FT synthesis are intrinsically sensitive to small amounts of poisons. In commercial operation, these catalysts must be replaced or regenerated after a certain operational period. The specifics of this syngas cleaning is based on economic considerations: the investment in gas cleaning must be weighed against decreased production due to catalyst poisoning. Therefore, new or novel catalysts that are resistant to contaminants may aid in the overall cost of the produced liquid fuel. These syngas contaminants, which result from the gasification of co-mingled coal and biomass, include (1) sulfur species, trace toxic metals, halides, and nitrogen species from coal, and (2) KCl and NaCl from biomass.

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

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

Questions—Contact Edgar Klunder (Edgar.Klunder@netl.doe.gov)

c. Concepts for Direct Liquefaction of Coal/Biomass Mixtures—Direct liquefaction of co-mingled coal/biomass mixtures has the potential to increase our energy security by making transportation fuels via these abundant domestic resources. In addition, the use of biomass as a feedstock can reduce the carbon footprint of this fuels-manufacturing process. Direct liquefaction processes include high-pressure hydrogenation, reactions with oils that can donate hydrogen, and enzymatic processes. The types of coals that have been used in direct liquefaction include lignite, sub-bituminous, and bituminous. The types of biomass that are available for direct liquefaction include corn stover, wood (forest residue, manufacturing residue, or short-rotation woody crops such as poplar), grass (switchgrass and mixed prairie grasses), and algae.

Grant applications are sought to demonstrate the feasibility of novel concepts for the direct liquefaction of a coal/biomass mixture (or mixtures) from the above-mentioned matrix of available feedstocks. The mixture chosen for research should be based on minimizing the transportation costs of bringing the feedstocks to the liquefaction plant. In addition, the mixture should contain at least 30 wt% (but not more than 50 wt%) biomass (dry basis). The research should be directed toward making transportation fuels at a cost that is competitive with the production of these fuels from petroleum. Literature reviews are not within the scope of this subtopic and will be rejected.

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

d. Concepts for Extracting Oil from Algae—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.

The biological capture of carbon dioxide and its subsequent conversion to a clean fuel is being considered as one method to recycle/reutilize the carbon from power plants. In particular, the carbon dioxide emitted from a power plant can be consumed during algae growth, and, because of its high lipid content, the algae can subsequently be utilized for the production of transportation fuels. However, it is currently estimated that the cost of an algae farming process with subsequent fuel production will be high. In order to reduce the overall projected cost for a large-scale operation, grant applications are sought to reduce the energy intensity and/or costs for two algae-to-fuel operations:

1. Dewatering (i.e., separating the algae from water). At small scale, dewatering is generally accomplished by filtration, followed by a centrifuge.

2. Algal-oil-extraction (i.e., recovering lipids from algae). The three methods that most often have been considered for extracting oil from algae are expeller/press, hexane solvent oil extraction, and supercritical fluid extraction. However, each of these methods has 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.

In addition to entirely new concepts, approaches of interest may be based on the traditional concepts described above, but must introduce an innovation that results in improved product recovery, process efficiency, and/or economics. Innovations that combine dewatering and lipid extraction are encouraged. On the other hand, the cultivation or harvest of algae is outside the scope of this subtopic. Applicants must obtain the algae slurry from their existing algae pond, etc., or source it elsewhere. (Grant funds may be utilized to purchase the algae-water slurry.) Additionally, literature reviews are not within the scope of this subtopic and will be rejected.

Questions—Contact Elaine Everitt (Elaine.everitt@netl.doe.gov

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27. 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 target efficiencies greater than 50%, the inlet temperature needs to be raised even higher (to 1500ºC (2732 ºF) or higher).

This topic seeks advances in alloy development for high temperature turbines, hot-gas-path component cooling techniques, novel coating methods for TBC/bond coat architecture for high temperature turbines, and rapid manufacturability of gas turbine components, enabling technologies for higher efficiency and lower emissions. **Grant applications are sought 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 gas 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. Materials systems of interest include modified superalloys and/or refractory metal alloys. 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 Robin Ames (robin.ames@netl.doe.gov)

b. Innovative Cooling Approaches—Novel and more effective cooling solutions are needed for the hottest sections of the gas turbine, including the combustor, transition section, first-stage nozzle, stators, rotor blades, and disks. Therefore, grant applications are sought for research and development to explore innovative surface cooling and internal cooling approaches, which 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.

For both types of cooling, 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 both coal syngas and high hydrogen fuels derived from syngas. Experiments to evaluate and demonstrate these approaches and their benefits are desirable. Also desired is the production of tools and techniques to allow the necessary component prototyping for the optimization of an economically viable solution.

Finally, grant applications should address the corresponding manufacturing technology needed to construct these complex three-dimensional structures with improved aerodynamic and cooling performances; that is, the grant application should demonstrate an understanding of how a particular cooling technique or approach can be manufactured and incorporated into engine components. Innovative or advanced manufacturing techniques that lead to low cost parts are desirable.

Questions - contact Robin Ames (robin.ames@netl.doe.gov)

c. Novel Coating Methods for Unique TBC/Bond Coat Architectures that Can Operate at Higher Temperatures—Thermal barrier coatings (TBCs) are used to protect high temperature turbines from the harsh environments encountered in IGCC systems. 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 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 in the BC. Therefore, grant applications are sought for research and development to explore new architectures for thermal-barrier-coating/bond-coat (TBC/BC) materials, such as yittria stabilized zirconia (YSZ), having a coefficient of thermal expansion (CTE) close to that of nickel based super-alloys. 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, based on manipulations of the chemistry and structure of the TBC.

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. It is expected that any proposed TBC/BC architecture will improve the stability of the TBC and the BC. The new materials must have low thermal conductivity (target is $\leq$ 0.7 W/mK), have low susceptibility to environmental effects, and withstand the temperature cycles that are expected. The TBCs must retain their low conductivity and strain tolerance at gas path temperatures up to 1500°C over many thousands of hours.

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, in order to enable 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.

Questions - contact Robin Ames (robin.ames@netl.doe.gov)

d. Rapid Manufacturing and Prototyping of Gas Turbine Components—Rapid prototyping manufacturing, or layer manufacturing techniques (LMTs), can greatly reduce the cycle time to produce parts for initial testing and verification of industrial gas turbine components. Today's state-of–the-art processes, such as 3D printing (stereo lithography), laser sintering, etc. are generally used for facsimile parts; as distinct from production components, such facsimile parts may be compromised with respect to dimensional accuracy and material properties. Hence, such parts, including rapid prototype parts manufactured by powder metallurgy, cannot currently replace production parts in gas turbines, even if they are compositionally identical. In addition, some rapid prototyping technologies can be expensive. Therefore, reductions in machine and material costs, combined with increases in machine throughput and improved LMT material properties, must be achieved for rapid manufacturing components to compete with their molded counterparts.

Grant applications are sought for research and development to explore innovative approaches to increase the density and mechanical properties of parts produced using LMTs. Grant applications must provide reliable data and processes for high-temperature-capable rapid manufactured materials (like powder metallurgy). Proposed approaches that focus on the application of rapid prototyping methodology to current state-of-the-art manufacturing processes, in order to significantly reduce the overall time and cost to market, are also of interest.

Questions - contact Robin Ames (robin.ames@netl.doe.gov)

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Subtopc b - Innovative Cooling Approaches

1. P. Chiesa and E. Macchi. "A Thermodynamic Analysis of Different Options to Break 60% Electrical Efficiency in Combined Cycle Power Plants," American Society of Mechanical Engineers (ASME) Journal of Engineering for Gas Turbines and Power, Vol. 126, pp. 770-

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28. FUEL CELL TECHNOLOGIES FOR CENTRAL POWER GENERATION WITH COAL

Improved power generation technologies will help the nation make more efficient, cost-effective and environmentally-responsible use of its abundant domestic coal reserves. Power generation systems based on solid oxide fuel cell (SOFC) technology are attractive alternatives to current technologies for coal-fueled central generation. SOFC systems are very efficient, with efficiencies ranging from 40 to over 60 percent (depending on system configuration). Electrochemical conversion in a SOFC takes place at lower temperatures (650ºC to 850ºC) than combustion-based technologies, resulting in decreased emissions, particularly nitrogen oxides. Furthermore, in a carbon-constrained world, SOFCs offer considerable opportunities with respect to both lower CO_2 generation (as a result of higher efficiency) and increased CO_2 capture. With these advantages, systems containing improved fuel cell technology, in combination with heat recovery subsystems and commercial CO_2 capture technology, can meet DOE goals that include 45-50% efficiency (coal Higher Heating Value {HHV} to electrical power), less than 2ppm NOx, and 90% carbon capture. Consistent with these goals, the DOE-sponsored Solid State Energy Conversion Alliance (SECA) will develop commercially-viable ($700/kW) SOFC power generation systems. This topic seeks advances in fuel cell technology for central coal power plants. **Grant applications are sought only in the following subtopics:**

a. Direct Utilization of Coal in Fuel Cells—High- and intermediate-temperature fuel cells offer significant advantages in the direct conversion of coal to electrical power. Systems incorporating such technologies have the potential to eliminate complex and costly intermediate coal gasification and clean-up processes. Moreover, high fixed and volatile carbon conversion may facilitate carbon capture. In concert with bottoming cycles to utilize waste heat (e.g., Rankine), such systems are expected to achieve very high efficiencies. Consequently, grant applications are sought to identify and characterize fuel cell concepts that directly utilize coal to produce electrical power.

Approaches of interest must focus on the development and evaluation of system concepts incorporating direct coal-fueled fuel cell stacks. The characterization should include fuel utilization, power density, degradation, emissions, etc., and the fuel cell concept should be evaluated experimentally. Illinois #6 coal is recommended for this study. Proposed concepts must (1) achieve 60 percent overall efficiency (coal HHV to electrical power), (2) capture greater than 90 percent of the carbon contained in the coal feed, and (3) be consistent with the SECA cost goal. Finally, lifetime effects (phase stability, thermal expansion compatibility, relevant degradation mechanisms, etc.) should be considered and characterized to the maximum extent possible.

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

b. Design and Analysis of Manufacturing Systems for SOFC Cells and Stacks—SOFC stacks, due to their modular nature, are intrinsically suited to modern high-volume manufacturing technology. For example, assuming an annual production of 500 MWe (gross stack output), with a unit cell active area of 500cm^2 operated at 400mW/cm^2, a large number of identical cells and a roughly equivalent number of interconnects are required. This requirement is analogous to the manufacture of computer chips. In most cases, well-established processes – such as screen printing and tape casting for cell manufacture, and stamping for interconnects – are utilized. These cells and interconnects, along with other parts (e.g., contact aids, manifolds, assembly hardware, etc.) are assembled into SOFC stacks that form the basis for large power generation systems. Leading SOFC developers are currently refining cell and stack designs in preparation for first-of-a-kind MW-scale proof-of-concept tests. Ultimately, optimized manufacturing will be an important contributor to a commercially-successful SOFC technology.

Grant applications are sought to perform conceptual design and analysis of a state-of-the-art high-volume manufacturing facility for SOFC stacks. Approaches of interest must (1) identify suitable commercially-available equipment, with automation employed as appropriate to reduce cell and stack cost; and (2) address technology, logistics, and facility costs (capital and operating). It is expected that selected projects will conduct the study in a bottom-up, activity-based manner – incorporating all aspects of raw material and purchased part acquisition and handling, cell and stack manufacture, labor requirements, facility overhead, and associated QA/QC processes and methodologies. It is envisioned that this work shall establish a baseline for stack manufacturing costs and yields, and requirements for optimized processes and equipment.

Phase I shall focus on the establishment of facility requirements and the evaluation of various layout and equipment options. In Phase II, one particular configuration shall be analyzed in detail. Given the technology-specific nature of SOFC cell and stack manufacturing, it is strongly suggested that applicants work with an established SOFC developer from the outset of the effort.

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

c. Post-SOFC Residual Fuel Oxidizer for CO_2 Capture—Because the fuel and oxidant (air) streams are separate in state-of-the-art Integrated Gasification Fuel Cell (IGFC) systems that incorporate SOFCs, they are particularly amenable to CO_2 capture. In these systems, the anode effluent is composed of CO_2, H_2O and residual H_2 fuel. The anode exit stream from a typical planar SOFC will have a temperature of 775°C-850°C (depending upon the particular stack technology and system design), will be near atmospheric pressure, and will contain up to 10% H_2 (by mole fraction).

Grant applications are sought to develop novel efficient and cost-effective technologies to oxidize the residual fuel in preparation for water removal/CO_2 isolation. A successful technology will be capable of oxidizing residual fuel with less than 100ppm of unreacted O_2 in the effluent stream, while maintaining an exit stream that is free from nitrogen or other gasses that would dilute the CO_2 concentration. Trace contaminants in the anode effluent are unimportant.

In Phase I, applicants shall identify and evaluate the proposed concept, prepare a preliminary assessment of cost, and assess how the technology integrates into an IGFC system. The most promising concept(s) shall form the basis of the Phase II work, which shall focus on the further development and laboratory-scale demonstration of the proposed technology. A detailed economic assessment of the proposed technology shall be performed in Phase II.

Questions - contact Joe Stoffa (joseph.stoffa@netl.doe.gov)

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2. Jan H.J.S. Thijssen. "Liquid Tin Anode for Direct Coal Conversion: A System Perspective," August 5, 2008, J. Thijssen, LLC, presented at the 9th Annual Solid State Energy Conversion Alliance (SECA) Workshop, Pittsburgh, PA. (Full text at: http://www.netl.doe.gov/publications/proceedings/08/seca/Posters/Thijssen.pdf)

Subtopic b - Design and Analysis of SOFC Cell and Stack Manufacturing Systems

1. "The Impact of Scale-Up and Production Volume on SOFC Manufacturing Cost", U.S. DOE/NETL, April 2007. (Full text at: http://www.netl.doe.gov/technologies/coalpower/fuelcells/publications/JT%20Manufacturing%20Study%20Report%20070522.pdf)

Subtopic c - Post-SOFC Residual Fuel Oxidizer for CO_2 Capture

1. "Innovative Coal / Fuel Cell Systems", Publications: Conference Proceedings, Presented during the 1st session of the 10th Annual SECA Workshop, Pittsburgh PA, July 14-16, 2009. (Full text available at: http://www.netl.doe.gov/publications/proceedings/pro_toc.html)

29. 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 three approaches that would contribute to more efficient production of oil and natural gas: (1) innovative, cost-effective processes or strategies for the viable production of methane from high-saturation, subsurface gas-hydrate accumulations within sandstone reservoirs; (2) innovative tools or methods to reduce cost and/or increase recovery efficiency associated with both conventional and unconventional oil and gas reservoir development; and (3) innovative tools or methods to reduce exploration, processing, and field development costs – and/or improve recovery efficiency – associated with oil sands, tar sands, oil shale, and unconventional gas. **Grant applications are sought only in the following subtopics:**

a. Methane Hydrates—Grant applications are sought to develop and evaluate innovative, cost-effective processes or strategies for the viable production of methane from high-saturation, subsurface gas-hydrate accumulations. Approaches of interest should (1) identify the most effective systems to optimize production viability for given geologic settings, (2) should include, and be developed in reference to, data on the geologic setting as documented by field drilling programs, (3) provide information on the production rates obtainable from gas-hydrate deposits, and (4) focus primarily on the physical development and testing of novel, integrated production systems an should not rely solely or predominantly on conceptual numerical modeling. Grant applications related to seafloor gas hydrate mounds or associated near seafloor occurrences, or which involve mining or other techniques that include sediment extraction are not of interest and will be declined.

Questions - contact Ray Boswell (ray.boswell@netl.doe.gov)

b. Development of Petroleum and Natural Gas Fields—Grant applications are sought to develop innovative tools or methods to reduce cost and/or increase recovery efficiency associated with both conventional and unconventional oil and gas reservoir development. Approaches of interest include, but are not limited to the development of (1) down-hole tools and methods that can decrease the time and cost associated with drilling hard formations, (2) drilling and stimulation methods that reduce the overall environmental footprint and/or minimize operational fluids handling (especially water use/reuse) associated with field development, (3) mobility control methods to increase overall recovery efficiency associated with carbon dioxide flooding, (4) innovative methods to identify and produce bypassed oil in mature fields, and (5) novel approaches to next- generation technology for full field development.

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

Questions - contact Albert Yost (albert.yost@netl.doe.gov)

c. Enhanced Recovery of Unconventional Resources—Grant applications are sought to develop innovative tools or methods to reduce geological and geophysical, environmental, processing, and field development costs – and/or improve recovery efficiency – associated with oil sands, tar sands, oil shale, and unconventional gas.

- For unconventional oil resources, approaches of interest include methods to (1) reduce the technical environmental constraints, (2) improve *in situ* and above-ground processing barriers to resource development, and (3) improve overall oil recovery efficiency.

- For unconventional gas resources, approaches of interest include (1) new or improved smart reservoir and full-field development methods, (2) innovative methods to reduce drilling flat time (non-productive time), and (3) fit-for-purpose drilling rig design or retrofit systems for high-rate–of-penetration drilling. Proposed approaches must be cost-effective and environmentally friendly, and should result in high gas-recovery efficiency across all producing formations.

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

Questions - contact Albert Yost (albert.yost@netl.doe.gov)

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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. (URL: http://www.netl.doe.gov/methanehydrates)

2. "The U.S. DOE Methane Hydrate R&D Program", Publications and Presentations of DOE Supported Methane Hydrate R&D 1999-2009, July 2009. (Full text at: http://www.netl.doe.gov/technologies/oil-gas/publications/Hydrates/pdf/MHBibliography.pdf)

Subtopic b - Petroleum and Natural Gas Field Development, Enhanced Recovery, and Emerging Resources

1. Applicants may review information about oil and gas programs at NETL website. (URL: http://www.netl.doe.gov/technologies/oil-gas/index.html)

30. 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 the change of CO_2 in 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 , as well as carbon stock and flux, in the major sinks identified by the SOCCR report (see Figure ES.1 therein).

Grant applications submitted to this topic should (1) demonstrate performance characteristics of proposed measurement systems, and (2) 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 Rick Petty (rick.petty@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; improved measurement technology for atmospheric CO_2 and its isotopes; and high accuracy and precision measurement of other trace greenhouse gases. Requests for specific grant applications are described in items (1) to (4) below:

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

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

(3) Grant applications are sought to develop lightweight sensors (approximately 100 grams) for measuring atmospheric CO_2. The sensors must be 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 platforms, and therefore must be insensitive to large changes in ambient temperature and pressure. The devices also must be able to operate on low power (e.g., 9v battery) and have a response time of less than 30 seconds.

(4) Grant applications are sought to develop new technology platforms that can be used to measure fluxes and/or concentrations of important trace greenhouse gas constituents, as well as the isotopes of carbon, methane, CO, and other trace species. Instrument designs should (a) place emphasis on determining the sources and sinks of carbon, CO, and trace species, and (b) 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. o

In general, new technology for measuring terrestrial biota and soil must be accomplished by *in situ* and/or non-invasive means, across a range of temporal scales (from seconds to days) and spatial scales (from millimeters to kilometers), depending on the system properties being observed. The remote sensing of organic carbon is also of interest – the term "remote sensing" means that the observation method is physically separated from the object of interest. All instruments must be portable and deployable in remote locations, and must not adversely impact the site of deployment. Two other approaches are also of interest: (1) the development of unique surface-based observations that are used for the calibration/interpretation of other remotely derived data; and (2) potential applications of CO_2 sensors via ballonsonde – however, remote sensing data acquisition by airborne or satellite platforms will not be considered.

Questions - contact Roger Rick Petty (rick.petty@science.doe.gov)

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2. "US Climate Change Technology Program—Technology Options for the Near and Long Term", Nov. 2003. (Full text at: http://www.climatetechnology.gov/library/2003/tech-options/index.htm)

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10. The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs, National Academy of Engineering/National Research Council Board on Energy and Environmental Systems, especially pp. 101-103 Washington, D.C.: National Academy Press, (2004). (ISBN: 978-0-309-09163-3) (Full text available at: http://books.nap.edu/books/0309091632/html/index.html)

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31. ENHANCED AVAILABILITY OF CLIMATE MODEL OUTPUT

Much of the nearly $2 billion annual research budget for the U.S. Global Change Research Program supports research from the Department of Energy, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and National Science Foundation (NSF) Studies supported by this research budget, include modeling and simulation of long-term climate change. Model output resulting from climate change projections is a valuable resource and the DOE has played a crucial role in providing such datasets to 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) Fourth Assessment Report to researchers for non-commercial purposes only. However, other users, particularly non-researchers that intend to use the data for commercial purposes, have been requesting access to the multi-model output. As the temporal and spatial resolution of models increase, vast amount of climate model output are generated; access and analysis of such data by non-researchers is a daunting challenge. **Grant applications are sought only in the following subtopic:**

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. Therefore, grant applications are sought to develop technology for making the output of these models more accessible to a variety of 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) methods for converting the data from existing data formats to formats required by users in the application communities; and (3) improved software frameworks and prototypes for data access by distinct application communities. Applicants are expected to document lessons learned in the experience of providing climate model output data to the non-research community.

Questions – contact Anjuli Bamzai Anjuli.Bamzai@science.doe.gov
Renu Joseph Renu.Joseph@science.doe.gov

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2. DOE's Atmospheric Radiation Measurement (ARM) Program provides improved scientific understanding of the fundamental physics related to interactions between clouds and radiative feedback processes in the atmosphere. (URL: http://www.arm.gov/)

3. DOE's AmeriFlux provides continuous observations of ecosystem level exchanges of CO_2, water, energy and momentum spanning diurnal, synoptic, seasonal, and interannual time scales. (URL: http://public.ornl.gov/ameriflux/)

32. ATMOSPHERIC MEASUREMENT TECHNOLOGY

World-wide energy production is modifying the chemical composition of the atmosphere. Such modifications are 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 that respond to this topic must propose Phase I bench tests of critical technologies. ("Critical technologies" refers to components, materials, equipment, or processes that overcome significant limitations to current capabilities.) In addition, grant applications should (1) describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities, and (2) 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 proposing only computer modeling without physical testing will be considered non-responsive.

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 ARM Aerial Facility (AAF). 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 have been used to stabilize a broad array of sensors related to weapons systems, cameras, and telescopes. However no such available platform is compatible with the light aircraft that are likely to serve as the vehicle for the bulk of the AAF radiation 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, due solely to pitch and roll movements of the aircraft.

Therefore, grant applications are sought to develop a stabilization system that is compatible with lighter aircraft. The stabilization system must (1) maintain a horizontally level positioning of the radiometers, and possibly other instruments, while in flight; (2) support radiometers that may weigh up to 10 kilograms (combined weight of the radiometers and associated instruments); (3) weigh no more than 30 kilograms (total weight of the stabilization system and instruments); (4) provide a leveling accuracy of at least 0.05 degrees (but 0.02 is desirable); and (5) provide 2 axes of pitch and roll stabilization. The range of correction will be a minimum of at least 10 degrees of roll and pitch (though up to 15 degrees is desirable), with a pitch rate of 10 degrees per second and a roll rate of 10 degrees per second.

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. As a consequence of this relationship, the moments of the path-length distribution can be used to (1) infer cloud properties, and (2) diagnose the process of absorption of shortwave radiation by greenhouse gases in the presence of complex cloudiness. In order 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 – ground-based differential absorption spectrometry of molecular oxygen could be used, 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. For an A-band instrument, the following specifications apply:

(1) The wavenumber resolution should be 2-4 cm^{-1}.

(2) The 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. This out-of-band rejection should not exceed $3x10^{-4}$.

(4) Instrument operation should provide a zenith-pointing narrow field-of-view (a few degrees), with an option for a hemispherical field-of-view as well.

(5) The signal-to-noise ratio should exceed 100:1 at the darkest wavelength, with integration times on the order of a minute.

Designs based on other solar spectral bands of oxygen are also of interest, provided that 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.

These spectrometers would be deployed by the DOE's Atmospheric Radiation Measurement (ARM) Program in support of its observational climate science mission. Thus, 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. In particular, applicants will be expected to coordinate with the ARM Science Team's A-band Focus Group, to ensure that the science requirements are met.

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

c. Measurements of the Chemical Composition of Atmospheric Aerosols—Improved measurement methods are needed for the real-time characterization of the bulk and the size-resolved chemical composition of ambient aerosols, particularly carbonaceous aerosols. Such improved measurements would be used to 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 the particles of an aerosol 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 these 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. Furthermore, 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. Proposed approaches that can measure aerosol chemical composition from airborne platforms would be of particular interest.

In order to address the deficiencies associated with current techniques, proposed approaches should seek to provide: (1) quantifiable results over a wide range of compounds, which is a deficiency of laser ablation aerosol mass spectrometer methods; (2) measurements over a range of volatility so that dust, carbon, and salt are detectable, which is a deficiency of thermal decomposition aerosol mass spectrometers; and (3) measurements with high time resolution, which is a deficiency of filter techniques.

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 the 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 aerosols or cloud droplets. Of special interest are volatile organic compounds (VOC) and intermediate volatility organic compounds (IVOC). Although VOCs and IVOCs partition primarily into the gas phase, they may react with gaseous oxidants or with existing aerosol particles and droplets to form a 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.

Grant applications also are sought to develop instruments to determine the total amount of carbon in these organic compounds. The data provided by these instruments would allow scientific insights to be gained regarding the reason for the underestimation of SOA production. (That is, 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?)

Finally, grant applications 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 gaseous HNO_3 (0.1 ppbv, 1 Hz), O_3 (2-3 ppbv, 10 Hz), and SO_2 (5 pptv, 1 Hz).

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 (1) methods for the efficient sampling of droplets; and (2) 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 can separate or discriminate between interstitial compounds and compounds that occur dissolved or suspended within cloud droplets.

Proposed instruments that are 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.

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

e. Aerosol Size Distributions—Knowledge of 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. Proposed approaches must address the influence of relative humidity and must be integrated with the simultaneous measurement of such properties as mass concentration, area (extinction), and particle number.

Grant applications also are sought to develop fast (~ 1 sec) and lightweight (suitable for sampling from airborne platforms) instruments for (1) particle size spectrum measurements in the 10- 600 nm size range, and (2) for cloud droplet/drizzle measurements (10–1000 µm size range). A related airborne measurement of great interest is a fast spectrometer for measurement of cloud condensation nuclei number concentrations over 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)

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33. 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 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 Research Challenge (IFRC) 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 IFRC 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—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. 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. Approaches of interest include the development of:

- integrated approaches where geophysical data are combined with other types of data (e.g., core analyses, well logs, hydrogeologic and geochemical information) to better constrain and evaluate flow and transport models;
- improved tools and methods for hydrogeologic characterization using cone-penetrometers and conventional well logging systems;

- innovative advances of temperature sensing technologies and approaches for hydrological characterization and monitoring from subsurface, surface, or airborne platforms; and
- 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.

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. 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 that address other contaminants will be declined. 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 – 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 cannot 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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34. IMAGING AND RADIOCHEMISTRY[

The Radiochemistry and Imaging Instrumentation Program advances the DOE mission by supporting radiochemistry and radionuclide imaging research into the real-time visualization of dynamic biological processes in energy and environmentally-relevant contexts. In particular, the program supports research that could be beneficial for metabolic imaging in living systems, including plants and microbial-communities that are relevant to biofuel production and bioremediation, and that are transferable for use in nuclear medicine research and in applications by NIH and industry. **Grant applications are sought only in the following subtopics:**

a. Radiochemistry and Radiotracers for Imaging—Grant applications are sought in three new areas of radiochemistry: (1) development of new chemical reactions to overcome the synthetic constraints of working with radioisotopes at high specific activity, in order to provide more generally applicable radiolabeling techniques; (2) construction of nanoparticle platforms, for incorporation of one or more imaging agents and targeting moieties; and (3) new automation technologies, in order to provide readily adaptable, versatile purification techniques (e.g., microfluidics kits) that can serve as transformational tools for radiotracer synthesis. Proposed approaches that directly advance the DOE mission will be given preference. However, approaches that do not involve radionuclide imaging capability are not of interest and will be declined.

Questions – contact Prem Srivastava (prem.srivastava@scienc.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, in order to study biologic processes not only in animals but also in plants and microbial communities. The application of radionuclide imaging to plants and microbial communities may require exploration of new scanner geometries and size scales to match the diversity of such new uses.

(2) Software for rapid image data processing and image reconstruction at the highest possible special and temporal resolutions.

(3) Hybrid imaging systems that combine advances in nuclear medicine image data in novel ways, in order to provide the high spatial resolution achievable with CT, MRI, mammography, optical, or ultrasound imaging;

(4) Methods of integrating *in vitro* and *in vivo* imaging instrumentation technologies for real-time radionuclide-based molecular imaging of biological function.

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

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35. GENOMIC SCIENCE AND RELATED BIOTECHNOLOGIES

The Department of Energy (DOE) supports research to acquire a fundamental understanding of biological and environmental processes. This research 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 Genomic Science program, namely, to develop a detailed understanding of the molecular machines of energy relevant plants and microbes (i.e., those that can further several DOE programmatic missions), and their networking in living cells and microbial communities. This information and capabilities thus gained will be progressively gathered and cross correlated in a developing Systems Biology Knowledgebase [1], 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 develop increasingly effective computational models of the microbial cell. For some of the subtopics below, capabilities already exist in a few laboratories; however, 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. Software Tools for the Systems Biology Knowledgebase (SBK)—The SBK is in a stage of active development and could benefit from complementary software tools. Grant applications are sought to develop such software tools, including, but not limited to:

1) new or improved tools for text and/or data mining, from either published literature or from other databases;

2) new or improved algorithms to construct dynamical networks that predict changes or influences of environmental factors on an organism's phenotype;

3) software to extract and integrate biologically relevant information across a diverse set of databases, which include genomic microarray, proteomic, metabolomic, and phenotypic data;

4) new or improved data formats and ontologies for interoperability between different databases or datasets; and

5) web-to-web services and/or semantic web tools for bioinformatics applications.

Questions contact: Susan Gregurick (susan.gregurick@science.doe.gov

b. Software tools for Export to the Commercial Sector—Genomic Science projects have led to the development of much software, which could be of considerable benefit to the broader community. However, the laboratories that developed the software generally do not have the resources or mission to provide continuing service to exterior users. Therefore, grant applications are sought to support the export of such software to companies that could, in turn, provide support services to user communities.

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

c. Systems for Growth of Fastidious Microbes—Using current protocols, most microbes remain either difficult to culture or even non-culturable. Therefore, grant applications are sought to develop systems that will improve culturing capabilities for energy relevant microbes and synergistic microbial consortia (especially those relevant to biofuels production), in quantities sufficient for biochemical and ohmics analyses. Specifically included are anaerobes, and photosynthetic and biofilm-forming microbes/consortia.

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

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, related enzymes, and sterols..

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

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36. SMART FACILITIES AND GREEN NETWORKS

a. Standardized Energy Measurement Interfaces, Integration with Facility Infrastructure, and Energy-Aware Algorithms—The understanding of power consumption from individual components of High Performance Computing (HPC) systems and datacenters is extraordinarily poor. Moreover, the power consumed by the hardware, the software that runs on the hardware, and the power and cooling infrastructure of the building in which the HPC system resides are all closely coupled. A power-efficient computing solution is needed to integrate these components through a standardized interface for exchanging energy consumption data (sensors) and enabling the fine-grained control of system elements (actuators). This subtopic addresses energy measurement interfaces, integration of building and HPC systems, and algorithms to improve energy efficiency:

- No standard now exists for collecting energy consumption information at either the node level or the component level within HPC systems. The availability of a fine-grained, standardized power measurement interface would enable development of power-aware software that uses performance metrics to make decisions to optimize power consumption, both at the system and micro-architectural level. Therefore, grant applications are sought to develop standardized information-collection interfaces capable of integrating fine-grained power consumption data from HPC nodes to (1) provide a global view of system energy consumption, and (2) enable autonomic systems to react to the current state of the environment.

- It also would be useful to integrate the information flow from HPC energy monitoring systems with HVAC systems, in order to provide real-time feedback and optimize the cooling and power management systems. Therefore, grant applications are sought to develop building infrastructure control systems that can monitor the information collected by standard energy-counter interfaces and optimize airflow and power distribution to achieve gains in the overall energy efficiency of the facility. One possible approach is to collect the instrumentation data and the facility's HVAC information into a formalized information repository that will enable both hardware and software components to react intelligently to environmental conditions. Such a repository could broaden the understanding of datacenter power consumption, assist in the planning of future facilities and HPC systems hardware, and make the information transparently available to third parties via open standards.

- Application performance data can be used to make the best use of power-saving features when waiting for constrained resources such as the interconnection network or memory. Power-aware algorithms can provide detailed hints to hardware about its resource requirements. Currently an open research area, one important aspect of this effort is the correlation of high level application behavioral metrics to power consumption. Therefore grant applications are sought to develop computer algorithms and resource scheduling systems that are capable of using information from the energy monitoring system to improve energy efficiency without sacrificing computational performance.

b. Green Computer Networks—The DOE operates a high-performance IP-based network called the Energy Science Network (ESnet). ESnet interconnects science facilities, supercomputer centers, and data repositories, and also enables large scientific collaborations through its extensive domestic and international peering points. The current ESnet backbone is constructed over multiple 10 Gbps Ethernet (and soon 100 Gbps) links. ESnet has developed its own dynamic provisioning protocol that exploits advanced network technologies such as MPLS, in order to deliver end-to-end on-demand circuits and bandwidth that can be reserved by users.

This protocol is coordinated through an international collaboration that works to ensure interoperability among other similar systems deployed in other research and education networks in the U.S. and Europe.

While critical to the advancement of science, the large computational research facilities connected by ESnet contribute to the emission of green house gasses (GHG) into the environment. Given ESnet's dynamic circuit-on-demand (DCD) capabilities, it may be possible to explore new types of computational and network architectures that not only benefit science but also reduce CO_2 emissions. However, there are many issues associated with re-orientation of DOE-relevant computing resources so that they can minimize GHG emissions raises a number of issues, including (1) where to site new resource centers; and (2) how to make optimal use of sites with renewable-energy sources, which otherwise would be unfriendly to computing and data resource siting. Embedded in these issues is the need to develop techniques to deal with intermittent power availability, physical security, accessibility for maintenance, accessibility by high-speed circuits, etc. In order to address and/or systematize the issues, grant applications are sought to:

- Develop software tools and services to support coordinated virtualized computational resources and dynamic network provisioning, in order to maximize the use of low-carbon-footprint or renewable-but-intermittent energy sources (e.g., wind, solar) for powering DOE-relevant computing and data facilities. Applicants are encouraged to consider the mechanisms necessary to co-schedule computational, storage, and network resources, in order to enable virtual machines on remote nodes to take advantage of intermittently-available renewable energy sources – perhaps via virtual machine migration – thereby minimizing carbon footprints.
- Develop and/or document a methodology for rating the GHG emissions from DOE-relevant computing and data facilities, in a way that would be useful to DOE scientists. The ratings should be based on the type and capacity of compute resources available, the type and capacity of data storage resources available, and the remote I/O strategy and capacity. Applicants should (1) work with ESnet to characterize the available peering points that are "closest" to the resources; and (2) develop interfaces to existing Grid resource virtualization systems, such as 5.   Nimbus. (URL: http://workspace.globus.org/), that can make use of such a catalogue in choosing among computing and data resources.
- Identify, document, and/or develop software to use ESnet's DCD/OCSARS dynamic circuit management control plane to build dynamic private VPNs, in order to provide full and redundant routing in cases where underlying physical systems – say, among a set of related parties (such as the nodes of a virtual/cloud computing environment) – may have changed as the result of virtual machine migration due to the issues noted above.
- Develop and/or document a methodology for evaluating realized and potential U.S. locations for large-scale wind and solar energy farms that are not well served by the existing electric transmission system and that could be useful to DOE-relevant computing resources. Approaches of interest should characterize (1) the availability of optical fiber points where ESnet could easily gain access to the fiber that serves energy regions of potential interest, and (2) the ease/difficulty of siting DOE-relevant computing and data facilities (including issues associated with physical security, access by maintenance personnel, etc.).

c. Low Power Portable Platforms Using Intelligent Sensor Processing—Various energy efficient technologies, such as parallel NAND flash and asynchronous computational processing, have been identified as part of an energy saving strategy for sensor data processing. The miniaturization of sensors, enabled by continued evolution of technology and increased dependence on computation through firmware/software, has created the possibility of field portable systems that reduce sample handling, provide rapid feedback capability, and enhance convenience. Grant applications are sought to develop energy efficient, intelligent sensor platforms, programmable via FPGA or similar technology, that can reliably support advanced sensing tasks (such as feedback controlled detection of metal composition in industrial environments, or rapid field analysis of ambient micro-organisms). These sensor systems should include a computational methodology for initiating the analysis, and storing and displaying the results, while consuming minimal power and being compact and portable.

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37. CLOUD COMPUTING

Cloud computing environments do not come preconfigured for High Performance Computing (HPC) applications. Users of such services must, in effect, build their own HPC software environment in order to make such services useful. This effort includes developing and/or configuring compilers, numerical libraries, parallel file systems, and data management tools, all of which are necessary for a computing environment that is typically provided by an HPC site. To address this issue, **grant applications are sought only in the following subtopic:**

a. Turn-Key HPC in the Cloud—An HPC environment, pre-packaged as a turnkey solution for cloud services, would enable DOE users, academic institutions, and even private companies to purchase access to cloud computing services in a pay-as-you-compute manner. Hence, grant applications are sought for innovative pay-as-you-go cloud HPC environments. Approaches of interest include, but are not limited to, the development and sale of pre-configured compute nodes for (1) existing systems, (2) software packages that run on the user's system and virtualize access to remote and distributed cloud computing resources, and (3) full-fledged web portals that implement a Software-as-a-Service (SAS) model to virtualize access to back-end cloud services.

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38. DATA MANAGEMENT AND STORAGE

a. Green Storage for HPC with Solid State Disk Technologies: From Caching to Metadata Servers—Most solid-state storage devices (SSDs) use non-volatile flash memory, which is made from silicon chips, instead of using spinning metal platters (as in hard disk drives) or streaming tape. By providing random access directly to data, the delays inherent in electro-mechanical drives are eliminated. The common consumer versions, known as flash drives, are compact and fairly rugged. Advantages attributed to SSDs include higher data transfer rates, smaller storage footprint, lower power and cooling requirements, faster I/O response times (up to 1000 times faster than mechanical drives), improved I/O operations per second (IOPS), and less wasted capacity.

Furthermore, upcoming processor chip designs from Intel and AMD will include SSD/FLASH controllers built on-board the CPU chip, in order to improve integration for laptop and embedded applications. Such technology is likely to enable a localized checkpoint-restart capability to mitigate increased transient failure rates on future ultra-scale computing systems. This increased level of hardware integration makes it clear that x86 server nodes, which incorporate SSD directly onto the node, are on the horizon.

In view of these developments, the DOE seeks to improve its understanding of the implications of SSDs for large-scale, tightly-coupled systems in High Performance Computing (HPC) environments. Therefore, grant applications are sought to further develop SSD technology as a cost-effective and productive storage solution for future HPC systems, including, but not limited to:

1) **Categorization of SSD failure modes** - The rate of deployment of SSDs in HPC environments will be artificially slowed until a better understanding of the failure modes of this new class of storage is achieved. Proposed approaches should categorize the type of failure (wire bond, cell wear-out, or other failure) and determine how the failures would be detected and/or repaired in a composite device fielded in an HPC environment.

2) **Use of SSD for node-local storage, for faster (localized) checkpoint/restart (CPR)** - If transient failures cause nodes to die, then SSD could be a viable approach for fault-resilience. However, for nodes subjected to hard-failures, the use of SSD could produce an even higher node failure rate, due to the inherent failure characteristics of the SSD; in this case, the SSD approach would not be viable for CPR. Approaches of interest should collect and analyze data on the known failure modes of existing SSD components vis-a-vis node failure modes, in order to determine if SSD presents an effective alternative to the checkpoint/restart of a shared file system.

3) **Use of SSD for scalable out-of-core applications** - Although node-local disk systems have been used to support some applications that use out-of-core algorithms (such as some components of NWChem), the failure rates of spinning disks have rendered this practice unfeasible. Rather, central file systems are used to support these out-of-core applications, greatly affecting their scalability. Approaches are sought to determine whether local SSD might be reliable enough to enable a scalable approach to out-of-core processing.

4) **Use of SSD for metadata servers -** Metadata servers subject disk subsystems to many very small transactions, a feature that is very difficult to support with existing mechanical/spinning-disk based systems. SSDs might respond better to the random-access patterns required for metadata servers, but may not perform as well for write functions. Approaches of interest should analyze the data access patterns of a typical HPC Lustre metadata server and, using an SSD performance model, determine how well an SSD-based system would respond to a metadata server load.

5) **Use of SSD for accelerated caching for the front-end of large-scale disk arrays –** The use of SSDs in caching for large-scale disk arrays is an emerging technology that is not well understood. Approaches are sought to determine of both its performance potential when subjected to real workloads and its fault resilience.

b. Data Management Tools for Automatically Generating I/O Libraries—Database-like, self-describing, portable binary file formats, such as Network Command Data Form (NetCDF) and Hierarchical Data Format (HDF), greatly enhance scientific I/O systems by raising the level of abstraction for data storage to very high-level semantics (of data schemas and relationships between data objects stored) rather than low-level details of the location of each byte of the data stored in the file. However, both NetCDF and HDF5 still rely on very complex APIs to describe the data schema, and many performance pitfalls can arise if the APIs are not used in an optimal manner. Consequently, application developers must invest considerable effort in creating their own “shim” I/O APIs that are specific to their applications, in order to hide the complexity of the general-purpose APIs of NetCDF and HDF5.

Grant applications are sought to develop software tools that not only would enable rapid prototyping of high-level data schemas but also would automatically generate a high-level API for presentation to application developers, thereby hiding the complexity of the low-level NetCDF and HDF5 APIs for managing the file format. Such tools also might use auto-tuning techniques to find the best performing implementation of an I/O method.

c. Integration of Scientific File Representations with Object Database Management Systems—Scientific file formats like Network Command Data Form (NetCDF) and Hierarchical Data Format (HDF5) have capabilities that closely match those of commercial Object Database Management Systems (ODBMS); yet, commercial ODBMSs provide much more sophisticated data management tools than are available to users of NetCDF and HDF5. Unfortunately, ODBMSs are not designed to accommodate parallel writes to the same data entry from multiple parallel writers. Furthermore, database storage formats are opaque and non-portable, and no file standard exists to facilitate the movement of data from one database system to another. By contrast, NetCDF and HDF5 both offer open, standardized formats and portable, self-describing binary formats for storing data represented as Object Databases.

Grant applications are sought to develop tools that enable seamless transfer of data from ODBMSs to self-describing scientific data file formats such as NetCDF and HDF5 and vice-versa. Approaches of interest should (1) enable a level of tool integration and migration in the commercial space that currently is not available, and (2) offer the scientific community access to a broad array of robust data management tools and much more powerful query-driven data analysis capabilities.

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2. NetCDF (Network Common Data Form). (URL: http://www.unidata.ucar.edu/software/netcdf/)

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39. MODELING AND SIMULATION OF INDUSTRIALLY-RELEVANT PROBLEMS

Over the past 30 years, the Department of Energy's (DOE) supercomputing program has played an increasingly important role in scientific research by allowing scientists to create more accurate models of complex processes, simulate problems once thought to be impossible, and analyze the increasing amount of data generated by experiments. Computational science has become the third pillar of science, along with theory and experimentation. However, despite the great potential of modeling and simulation to increase understanding of a variety of important engineering challenges, High Performance Computing (HPC) is underutilized by industry. To demonstrate the utility of the simulation approach, **grant applications are sought only in the following subtopic:**

a. Simulation of Engineering Problems—Grant applications are sought for the simulation of engineering problems that have relevance both to industry and to the mission of DOE.

Approaches of interest include, but are not limited to, simulations:

- of three-dimensional unsteady fluid flows, such as the flow over wind-turbine blades;
- of unsteady combustion, such as near blow-off dynamics;
- of combustion instability in gas-turbine combustors;
- aimed at an improved understanding of the environmental impact of energy-production technologies;
- to guide the development or monitoring of nuclear energy generation and management technology, including (1) extending the life of existing nuclear plants, (2) building and operating

new reactors of advanced designs, (3) developing new uses for nuclear energy, such as producing hydrogen, and (4) dealing with nuclear waste;

- that facilitate procedures and patient monitoring for nuclear medicine;
- that support development and/or monitoring of carbon sequestration methods and technology;
- involving yield predictions for biofuel feedstocks; and
- of two-phase flows, such as fuel sprays for internal combustion engines.

Grant applications must establish how the proposed research relates to the achievement of one or more energy-related goals, such as improved energy efficiency, reduced emissions, development of green energy alternatives, and/or reduced costs for environmentally-friendly energy technologies.

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40. CYBER-SECURITY AND NETWORKING

The data requirements of the large-scale science experiments funded by DOE's Office of Science continue to expand at an exponential rate. In an attempt to keep up with that demand, the Energy Sciences Network (ESnet) is currently deploying multiple state-of-the-art 10 Gigabit per second (10 Gbps) circuits that link the remote experiments to and among the national laboratories, and to other domestic and international institutions, via connections with other national and international research and education networks. This capability will be expanded to 100 Gbps circuits in the near future to match the continued growth of high-speed scientific data movement requirements. In order to protect the scientific and computational assets on which scientific discovery depends, the cyber-security capabilities of the national laboratories must scale to 100 Gbps as well.

However, cyber-security at 100 Gbps is unexplored territory, and the development of solutions in this space will be challenging. For example, the 100 Gbps security systems must not impede the high-speed data flows, such as the requirement for 100 Gbps line rate or "wire-speed" operation, on which large-scale science depends. In addition, the difference between Enterprise traffic (e.g. day-to-day business web and email) traffic – which is assumed to be the operational profile for many commercial cyber security solutions – and science traffic will be even greater at 100Gbps, since science traffic has grown to be the dominant user of ESnet. To address these challenges, **grant applications are sought only in the following subtopic:**

a. NIDS Front-End for Load Balancing at 100 Gbps—A number of DOE Labs, as well as a number of universities, use the Bro Intrusion Detection System (IDS). In order for the Bro IDS to operate on network links that exceed 1 Gbps, NIDS – a scalable Bro cluster, known as NIDS has been developed and demonstrated to be scalable on the analysis backend. However, for NIDS to do traffic analysis on links of 10Gbps and above, a front-end system, which performs load-balancing to split the analysis across multiple commodity systems on the backend, is required. This front-end system should use a flow-based scheme to provide load balancing, so that all packets belonging to the same flow go to the same backend node, thereby minimizing the communication of state among backend nodes. In order to achieve this load balancing, various hashing schemes have been analyzed, some optimal schemes have been identified, and experiments have been conducted with existing hardware on 10 Gbps links. However, the ESnet is migrating to 100Gbps links. Therefore, grant applications are sought to develop a NIDS front-end capable of load balancing packets on 100 Gbps links, including 100-Gbps-capable hardware that is compatible with NIDS.

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41. HIGH PERFORMANCE COMPUTING SYSTEMS

a. Computing Applications Porting—There is a growing need for a broad range of scientific and engineering application software that can be utilized on terascale and petascale computer systems. Currently, few commercial vendors are addressing this need. Grant applications are sought to develop technology for porting applications to a myriad of High Performance Computing (HPC) platforms. Proposed approaches could involve scaling studies, algorithm re-design, software re-architecting, software testing, and design changes, in order to tune and optimize the use of applications on these massively parallel supercomputing systems. Some specific topics of interest in this area include:

1) Moving legacy codes to new architectures and new machines.
2) Writing new codes to accomplish new powerful capabilities.
3) Formulation of new approaches to solve known problems on large scale platforms.
4) Algorithm development to convert the new formulations into viable, hardware architecture-aware codes.

5) Methods to assure efficiency and scalability across a broad horizon of applications and algorithms.
6) Embracing multiple cores and accelerators in massively parallel architectures.
7) Methods for verification and validation that lead to certification of codes.

Research related to these topics should be led by software providers. Collaborations with DOE laboratories – in the form of access to HPC resources, as well as in providing expertise in targeted science and engineering domains – may prove to be quite beneficial.

b. Multicore OS Technology—Current operating systems (OS), such as Linux, are designed to work exclusively on low-concurrency homogeneous multicore systems. However, current technology trends are moving towards heterogeneous multicore environments that exhibit massive parallelism (not anticipated by Linux) and complex memory hierarchies that are not necessarily cache-coherent (such as Cell, and GPUs). Also, High Performance Computing (HPC) OS solutions require a modular approach to OS design that would allow OS services to be configured in flexible manner, in order to meet the needs of each individual application – as opposed to the current all-or-nothing approach where micro-kernels offer minimal services (providing more memory to the application and to minimize OS jitter) and full OSs are required to offer robust scripting environments (at a cost of memory footprint and complexity). HPC users need a dynamically configurable OS environment – a modular configurable platform – to meet these diverse requirements. It is unlikely that incremental changes to conventional OS implementations will result in a solution that meets these emerging requirements. The DOE FastOS program has demonstrated initial technological approaches to OS technology that are capable of operating on non-conventional memory hierarchies and heterogeneous "accelerator" based platforms. Grant applications are sought to bring such approaches into a mainstream turn-key OS solution that offers value to the broader HPC environment. Grant applications also should demonstrate the applicability of the proposed approach to embedded/consumer-electronic devices, which also are sensitive to memory requirements, and are increasingly concerned with performance and management of scheduling for parallel hardware.

c. Compiler Research for Code Instrumentation—Understanding the cache-footprint and memory bandwidth requirements for a given code is essential for (1) setting the parameters for future High Performance Computing (HPC) system designs, and (2) optimizing system parameters to develop energy-efficient computing designs that do not compromise computational efficiency. However, understanding these parameters using conventional PAPI or other performance-counter-based tools has proven to be extremely difficult and inaccurate over time. Also, the performance-counter infrastructure provided by modern microprocessor designs tends to be very narrow in scope and incomplete for the task of fully understanding code requirements. Grant applications are sought to create compilers capable of integrating performance instrumentation directly into application codes that can work in conjunction with PAPI and hardware performance counters, so that performance data can be gathered transparently at runtime and then fed-back to a re-compilation process that would further optimize code for subsequent runs on HPC systems. Grant applications also should address how this same instrumentation data could be used to (1) better understand the DOE workload, and (2) provide guidance for the hardware design of future HPC systems (e.g. cache-sizes, instruction mix, memory bandwidth requirements, and communication requirements).

d. Journal-based Storage for Parallel I/O—In the research community, the advantages of a journaling approach to scalable parallel I/O systems has been demonstrated by a number of examples, including the Parallel Log-Structure File system (http://institute.lanl.gov/plfs/) and PVFS2. This approach is substantially different from current parallel file systems, such as GPFS and LUSTRE. The commercialization of these journal-based file systems would offer the opportunity to significantly improve the performance of High Performance Computing (HPC) I/O subsystems, and could provide substantial opportunities for non-HPC applications as well. However, such file systems require significant advances in management infrastructure and robustness before they can be migrated into commercial solutions. Therefore, grant applications are sought to develop robust, commercially-viable implementations of journal-based file systems that have the security and management capability necessary for broad system deployment and commercial application.

e. Advanced, Multi-platform Build Systems—Currently, build systems are the weakest link in portable High Performance Computing (HPC) codes and library design. Despite language standardization, and POSIX library standardization, it is extraordinarily difficult to design application build environments that are portable across the broad-variety of HPC systems. As a symptom of the poor quality of today's build environments, the failure of many application builds is due to an inability to locate the library that contains the implementation of particular subroutine calls that match the needs of a user application. The remedy is to globally search for the missing implementation by using various UNIX system tools. Part of the problem is that the current symbol resolution depends on the use flat-file representations of rather than on the use of a more search-driven database storage format. Grant applications are sought to create advanced build systems and symbol resolution frameworks that are capable of storing all library subroutine calls, related data-structures, and global variables in a query-able database representation, in order to facilitate more productive and portable build environments.

f. Commercialization of HPC Programming Environments—Within the HPCS program, considerable effort has gone into the creation of Integrated Development Environments (IDEs) and programming tools. For example the Photran extension to the Eclipse IDE enables automatic analysis of Fortran+MPI code for parallel systems. However, an additional effort is required to integrate this environment with existing HPC system environments at the Leadership Computing Facilities and other HPC environments. Therefore, grant applications are sought to further the commercialization of IDEs (such as the Eclipse IDE for MPI+Fortran applications) so that they can be integrated into mainstream practice at computing clusters and other leading-edge "leadership" HPC environments.

g. Portable Linux Distributions for HPC—Linux-based login and batch queue environments are prevalent in High Performance Computing (HPC) environments. However, differences in deployments, in configuration across clusters, and in parallel computing resources present challenges to the portability and ease of use of HPC software. Therefore, grant applications are sought to develop a Linux distribution technology that that brings together several important HPC software portfolios. Approaches of interest include the development of:

- A software suite – including SciDAC supported codes such as Chombo, PETSc, Zoltan, ScaLAPACK, Hypre, Sundials, VisIt, GridFTP, Metis, and others in common use at HPC centers. Such a suite could provide valuable enhancements to software users and maintainers, if it were organized as a well tested set of version-controlled software modules. RPMs may be one way to accomplish this goal.

- A fully working set of open source compilers, MPI, HPC libraries, and performance tools, layered on top of an existing Linux distribution. Such a set could provide a turn-key solution for the HPC space. Commercial software also could be bundled as part of that product.
- An operating system image that integrates the pieces of a full featured HPC environment, and is suitable for booting as a live cd or in a virtual machine. Such an image could bring SciDAC supported software to the desktop, small clusters, and cloud computing environments; could bridge the gap between those environments and petascale computing; could be used pedagogically to "bring HPC to your laptop"; and could grow into a profound tool for HPC interoperability.
- An interface that brings HADOOP (open source map-reduce software) to parallel computers with batch queue environments. Most HADOOP instances are set up on clusters designed around search functions and are operated in a persistent manner as opposed to a time-shared manner. In a batch queue environment, the situation would be very different; the HADOOP infrastructure would need to be instantiated and shutdown within each job. An easy on/off HADOOP would make it easier for scientists to search and analyze their data.

h. Software Fault Detection—Software errors are the dominant mode of service interruption over the lifetime of most HPC resources. The development of software that tracks and analyzes software faults in an organized way could yield valuable benefit to users and managers of HPC resources. Therefore, grant applications are sought to develop:

- Low level mechanisms to conduct detailed unit testing, benchmarking, and pattern detection of software faults. Such mechanisms could be integrated into a high level data center dashboard, thereby minimizing the staff effort required to track failures on the basis of log files and after-the-fact examination. Although datacenter dashboards already exist, most are focused on transaction processing rather than on parallel computing. Likewise, existing work has emphasized revenue rather than scientific metrics, detailed application performance, and parallel efficiency.
- Change management software that gathers and records software and configuration data over time. Such data could be joined with benchmark or workload data to provide a perspective on how software upgrades and configuration changes can impact performance.

In addition, there is a need to develop software for fault analytics. When a large parallel computer is booted, many layers of software start in sequence, without checking to see that the resources, files, and services that they require are indeed available. One consequence is that one layer may freeze or malfunction, leading to an ensuing cascade of events that may require human intervention to unwind. Therefore, grant applications also are sought for a mechanism to detect (or manually enter) software dependencies on an HPC resource and translate those dependencies into basic unit tests that can be used to check a machine's degree of readiness for production use. Such dependency tests could be useful both before and after a fault. Similarly, when a software fault occurs, such tests could be invoked to obtain a richer assessment of the situation surrounding the fault. (In some cases, the level of detail is not very rich – only a single number or error code – which leads to difficulties in determining why a job failed.) Although an appropriately trained system administrator can read the logs and often diagnose the failure, an automated system is preferred.

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42. COLLABORATION, SCIENTIFIC VISUALIZATION AND DATA UNDERSTANDING

Scientific visualization and data management are critical enabling technologies for computational science research, providing scientists with the capability to extract scientific insights from data sets generated by simulations and experiments. The combination of sensor networks, high-end computing, and more experiments are expected to generate several petabytes of structured and unstructured multi-dimensional data sets per year. Thus, the next-generation of scientific visualization systems will have to outperform today's systems. This topic seeks visualization and collaborative data analysis systems that are attuned to the needs of domain scientists and/or decision makers and address important data management and domain-specific science challenges. Limited computer resources at DOE facilities can be made available to successful Phase I applicants for proof-of-concept studies, if properly justified in the grant application. Additional computer resources also can be made available during Phase II to further develop the proposed concepts. **Grant applications are sought only in the following subtopics:**

a. Collaborative Data Analysis and Visualization—Advances in high performance network capabilities and collaboration technologies are making it easier for large geographically-dispersed teams to collaborate effectively. Despite these advances, efforts to mitigate the effects of separation have not kept pace with the advance of technology, especially for research teams that use major computational resources, data resources, and experimental facilities supported by DOE.

While the importance of collaboratories is expected to increase in the future, significant barriers must be overcome for collaboratories to achieve their potential. In particular, research and development efforts are needed to provide (1) remote access to facilities that produce petabytes/year; (2) remote users with an experience that approaches "being there;" (3) remote visualization of large-scale data sets from computational simulation; and (4) effective remote access to advanced scientific computers. In addition, to be part of a useful investigatory scientific research environment or an instructional environment, visualization systems and data analytics must be integrated with supporting computational science technologies such as high-end computing, data management, data storage/retrieval, I/O capabilities, and networking capabilities.

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 process 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.

b. Comparative Visualization—Multiple 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 seeking to validate models or experimental measurements, or to perform parameter studies and sensitivity analyses, generate multiple instances of data sets, which need to be compared and/or analyzed as a set. Frequently, analysts and decision makers need to compare the outcomes of analytical processes and/or differences between data sets. Despite these comparison needs, many studies have documented the very poor human capability for detecting change visually, a phenomenon known as change-blindness. Therefore, grant applications are sought to develop algorithms and software systems that provide comparative visualizations, or visual representations of the differences between data sets and/or processing outcomes.

c. Distance/Remote Visualization—A capability for scientists to analyze, visualize, interact with, and understand their research results is critical to effective science. Yet, these activities are significantly hampered by the fact that the scientists often are in geographically different locations than the supercomputing resources they work on. 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. Therefore, grant applications are sought to develop products to address these visualization needs. Approaches of interest include, but are not limited to, the development of (1) latency-tolerant software applications for delivering interactive visualization results to remote consumers, using distributed and parallel computational platforms; (2) software applications for delivering visualization results that gracefully accommodate the wide variance in network capacity; and (3) middleware applications for resource- and condition-adaptive partitioning of the visualization pipeline to meet performance or capability targets.

d. Interactive Visualization and Analytics— Human learning and insight are active processes that require more than examining an image; yet, although it is assumed that existing visualization systems support knowledge discovery, in fact, they just present graphics. Typically the visualizations are not deeply integrated with methods and tools that would enable insight into the processing of the data. Existing systems also lack the ability to (1) allow users to interactively explore data to facilitate discovery, and (2) capture the process of visual analysis and interaction, in order to enable validation and provide insight into best practices.

Grant applications are sought for new software applications and tools that enable integrated interactive visualization and analytic discovery. Approaches of particular interest include, but are not limited to (1) network visualization and analysis, including computer networks, sensor networks, power grids, social networks, etc; (2) computational fluid dynamics; and (3) high-end computer system performance.

e. Techniques for Integration and Interactive Visual Analysis of Multi-Disciplinary Scientific Data—Today's scientific applications include data from multiple disciplines, such as (1) an ecological study that includes chemistry, biology, and earth science data; or (2) a climate study that includes data about the atmosphere, oceans, sun spots, glaciers and ice dynamics, hydrology, human populations, etc. Grant applications are sought to develop novel products for integrating such data for the purpose of common examination and analysis. Approaches of interest include, but not limited to, integration and interoperability across multiple spatio-temporal scales, heterogeneous data formats, etc.

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3. Ray Bair, et al. "Planning ASCR/Office of Science Data-Management Strategy", Data Management Challenge Workshop Report, Sept. 2003. (Full text available at: http://www-conf.slac.stanford.edu/dmw2004/docs/DM-strategy-final.doc)

4. "Visualization and Knowledge Discovery", Report from the DOE/ASCR Workshop on Visual Analysis and Data Exploration at Extreme Scale, Oct. 2007. (Full text at: http://science.doe.gov/ascr/ProgramDocuments/Docs/DOE-Visualization-Report-2007.pdf)

5. Hank Childs and Mark Miller. "Beyond Meat Grinders: An Analysis Framework Addressing the Scale and Complexity of Large Data Sets", Proceedings of SpringSim High Performance Computing Symposium (HPC 2006), Huntsville, AL, pp. 181-186, April 2-6, 2006. (Full text available at: http://graphics.idav.ucdavis.edu/publications/print_pub?pub_id=891)

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43. 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 detector elements 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.

Also, many DOE labs have existing investments in large-scale tape robot technologies, which are at this point the most cost-effective way to store petabyte-sized datasets. Grant applications are sought for (1) the development of innovative storage technologies that not only can use existing cartridge and tape formats but also will significantly increase the storage density and capacity, increase data read and write speeds, or decrease costs; and (2) innovative software technologies to allow file-system-based user access to 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, data transfers to Tier 2 and Tier 3 centers from multiple data provenance – with an aim for least wait-time and maximal coordination (coordination of otherwise chaotic transfers), 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 Grid middleware, such as the Virtual Data Toolkit (VDT), as the foundation used by Nuclear Physics and other science communities. Applicants that propose data distribution and processing projects are encouraged 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; (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; and (3) for hardware and software to significantly improve the energy efficiency and reduce the operating costs of computer facilities at Nuclear Physics research centers.

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

c. 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 (2) Cloud Computing, which could offer an application-specific computing environment by allowing the 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 that do not have the necessary application software environment installed.

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

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44. 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 46 (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 devices include (1) 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); (2) inhomogeneous semiconductors such as SiGe; and (3) device processes such as silicon-on-insulator (SOI) or silicon-on-sapphire (SOS).

Areas of interest regarding systems include (1) 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), (2) advanced high-bandwidth data links are of interest.

Grant applications also are sought for 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, and thicknesses 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 (which 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 parasitics; (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.

Lastly, highly-segmented detectors with pixels smaller than 100 microns present a significant challenge for integration with front end electronics. New monolithic techniques based on vertical integration and through-silicon vias have potential advantages over the current bump-bonded approach. Grant applications are sought to demonstrate reliable, readily-manufacturable technologies to interconnect silicon pixel detectors with CMOS front-end integrated circuits.

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

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

45. 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; 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. All grant applications must explicitly show relevance to the nuclear physics program. **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 hydro forming or spinning of seamless SRF cavities.

Grant applications also are sought to develop (1) methods for manufacturing superconducting radio frequency (SRF) accelerating structures with $Q_0>10^{10}$ at 2.0 K, or with correspondingly lower Q's at higher temperatures such as 4.5 K; and (2) advanced fabrication methods for SRF cavities of various geometries (including elliptical, quarter and half wave resonators) to reduce production costs. Industrial metal forming techniques, especially with large grain or ingot material, have the potential for significant cost reductions by simplifying sub-assemblies – e.g., dumbbells and beam tube – and reducing the number of electron beam welds.

Grant applications also are sought to develop (1) improved superconducting materials that have lower RF losses, operate at higher temperatures, and/or have higher RF critical fields than sheet niobium; and (2) 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 involving atomic layer deposition (ALD) synthesis should identify appropriate precursors and create high quality Nb, NbN, Nb_3Sn, or MgB_2 films with anti-diffusion dielectric overlayers.

Grant applications also are sought for laser surface glazing of niobium for surface purification and annealing in ultra-high vacuum.

Finally, grant applications are sought to develop 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 (1) yield microscopically smooth (R_q< 10 nm / 10μm^2), crystallographically clean bulk niobium surfaces; and/or (2) reliably remove essentially all surface particulate contaminates (> 0.1 μm) from interior surfaces of typical RF accelerating structures. Grant applications aimed at design solutions that enable integrated cavity processing with tight process quality control are highly sought.

For questions related to items (1) through (7) in the first paragraph of this subtopic, contact Dr. Robert Rimmer at Thomas Jefferson Laboratory (rarimmer@jlab.org). For all other questions, contact Dr. Charles Reece at Thomas Jefferson Laboratory (reece@jlab.org).

b. Radio Frequency Power Sources—Grant applications 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. Grant applications also are sought to develop computer software for the design or modeling of any of these devices; such software should be able to faithfully model the complex shapes with full self-consistency. Software that integrates multiple effects, such as electromagnetic and wall heating, is of particular interest. For questions or further specifications, 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).

Grant applications also are 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, and 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° or less of phase and 0.1% amplitude) and electron acceleration structures (0.1° 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) development of rapidly tunable RF systems for applications such as non-scaling fixed-field alternating gradient accelerators

(FFAG) and rapid cycling synchrotrons, either for providing high power proton beams or for proton therapy.

Grant applications also are sought to develop software for the design and modeling of the above systems. Desired modeling capabilities include (1) charged particle dynamics in complex shapes, including energy recovery analysis; (2) the incorporation of complex fine structures, such as higher order mode dampers; (3) the computation of particle- and field-induced heat loads on walls; (4) the incorporation of experimentally measured 3-D charge and bunch distributions; and (5) and the simulation of the electron cloud effect and its suppression. For questions related to software design and modeling, contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory mailto:(benzvi@bnl.gov).

A high-integrated-voltage SRF cw crab crossing cavity is also of interest. Therefore, grant applications are sought for (1) designs, computer-modeling, and hardware development for an SRF crab crossing cavity with 0.5 to 1.5 GHz frequency and 20 to 50 MV integrated voltage; and (2) beam dynamics simulations of an interaction region with crab crossing. One examples of a candidate technologies would be a multi-cell SRF deflecting cavity. For questions or further specifications, contact Drs. Yaroslav Derbenev, Geoffrey Krafft or Yuhong Zhang at Thomas Jefferson Laboratory (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org). For questions related to multicell SRF deflecting cavities, Dr. Ilan Ben-Zvi at Brookhaven National Laboratory mailto:(benzvi@bnl.gov) also may be contacted..

Grant applications also are sought to develop Hi-B solenoids with minimum fringe field – using 9 T solenoids in the same cryo module of a SRF accelerator as niobium cavities requires the external fringe fields to be very low. The problem is complicated by the inclusion of dipole correction coils and limited space, and the reduced field must be small in multiple directions. the development of cost-effective, compact units would make cryo module production simpler and cost effective. For questions, contact Dr. Al Zeller, NSCL/MSU (zeller@nscl.msu.edu).

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 accelerator 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 mailto: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) methods and/or devices for reducing the emittance of relativistic ion beams – such as coherent electron cooling, and electron or optical-stochastic cooling; (3) 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); (4) techniques for *in situ* beam pipe surface coating to reduce the ohmic resistance and/or secondary electron yield; and (5) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients.

Accelerator techniques for medium energy rings with high space charge are also of interest. Therefore, grant applications are sought to develop methods for maintaining low 4-D emittance in low and medium energy proton rings (10-30 GeV) with high space charge. Approaches of interest could include, but are not limited to, (1) novel magnet lattices designs, (2) advanced beam injection and ejection schemes, and (3) advanced studies on ring impedance and its reduction. Interested parties should contact Drs. Yaroslav Derbenev, Geoffrey Krafft or Yuhong Zhang at Thomas Jefferson Laboratory (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org), for further specifications.

Accelerator techniques for energy recovery linacs (ERL)based electron beam cooling are of high interest for next generation colliders for nuclear physics experiments**.** Therefore, grant applications are sought to develop (1) designs, computer-modeling, and hardware for a fast beam-switching kicker with 0.5 ns duration and 10 to 20 kW power in the range of 5-50 MHz repetition rate; and (2) optics designs and tracking simulations of beam systems for ERL and electron circulator rings, with energy range from 5 to 130 MeV. Examples of candidate technologies include SRF deflecting cavity, pulse compression techniques, and beam-based kicker. Grant applications also are sought to develop computer software for the design, modeling and simulating any of these devices and beam transport systems. For questions and further specifications, contact Drs. Yaroslav Derbenev, Geoffrey Krafft or Yuhong Zhang at Thomas Jefferson Laboratory (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org). For further information related to coherent electron cooling, please contact Dr. Vladimir Litvinenko at Brookhaven National Laboratory (vl@bnl.gov)

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 (1) intra-beam scattering, (2) spin dynamics, (3) polarized beam generation including modeling of cathode geometries for high current polarized electron sources, (4) electron cooling, beam dynamics, transport and instabilities; and (5) 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. Grant applications also are sought to develop graphical user interfaces for problem definition and setup. For questions, contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov).

e. Polarized Beam Sources and Polarimeters— With respect to polarizing sources, grant applications are sought to develop (1) polarized hydrogen and deuterium (H-/D-) sources with polarization above 90%; (2) cw polarized electron sources delivering beams of ~10 mA, with longitudinal polarization greater than 80%; (3) ~28 MHz cw polarized sources delivering beams of ~500 mA, with polarization greater than 80%; and (4) 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, contact Dr. Matthew Poelker at Thomas Jefferson Laboratory (poelker@jlab.org).

Grant applications also are sought to develop (1) methods to improve high voltage stand-off and reduce field emission from high voltage electrodes, compatible with ultra-high-vacuum environments; (2) 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; (3) 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 (4) a cost-effective means to obtain and measure vacuum below 10^{-12} Torr.

Grant applications also are sought for (1) advanced software and hardware to facilitate the manipulation and optimized control of the spin of polarized beams; (2) advanced beam diagnostic concepts, including new beam polarimeters and fast reversal of the spin of stored, polarized beams; (3) novel concepts for producing polarizing particles of interest to nuclear physics research, including electrons, positrons, protons, deuterons, and ^{3}He; and (4) credible sophisticated computer software for tracking the spin of polarized particles in storage rings and colliders.

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

f. Rare Isotope Beam Production Technology— Grant applications are sought to develop (1) ion sources for radioactive beams, (2) techniques for secondary radioactive beam collection, charge equilibration, and cooling; (3) technology for stopping energetic radioactive ions in helium gas and extracting them efficiently as high-quality low-energy ion beams; and (4) advanced parallel-computing simulation techniques for the optimization of both normal- and super-conducting accelerating structures for the future rare isotope facility.

Grant applications also are sought to develop radiofrequency devices for ion transport along surfaces. The transport of ions along walls of gas-filled vacuum chambers by means of a series of electrodes, to which radiofrequency voltages are applied, has gained significant importance, not only in nuclear physics for the stopping and thermalization of rare isotope beams but also in ion chemistry. Ultra-high vacuum compatible large-size printed circuit boards, or similar approaches, together with tailored RF circuitry, are considered most promising for providing low-maintenance reliable performance. Interested parties should contact Dr. Georg Bollen, FRIB/MSU (bollen@frib.msu.edu).

Grant applications also are sought to develop fast-release solid catcher materials. The stopping of high-energy (>MeV/u) heavy-ion reaction products in solid catchers is interesting for realizing high-intensity low-energy beams of certain elements and for the parasitic use of rare isotopes produced by projectile fragmentation. The development of suitable high-temperature materials to achieve fast release of the stopped rare isotopes as atomic or single-species molecular vapor is required. Interested parties should contact Dave Morrissey, NSCL/MSU (morrissey@nscl.msu.edu).

Grant applications also are sought to develop techniques for efficient rare isotope extraction from water. Water-filled beam dumps, considered in the context of high-power rare isotope beam production, could provide a source for the harvesting heavy-ion reaction products stopped in the water. In the case of interest contact Dr. Dave Morrissey, NSCL/MSU (morrissey@nscl.msu.edu).

Lastly, 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. Grant applications also are sought for special designs that are applicable for use in high radiation areas. (Additional needs for high-radiation applications can be found in subtopic "d" of Topic ___, Nuclear Physics Detection Systems, Instrumentation and Techniques.)

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

g. 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 proton/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 that have bandwidths of 100+ kHz.

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

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46. 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 at universities and national user facilities, including the Argonne Tandem Linac System (ATLAS) at Argonne National Laboratory and Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory (ORNL). In addition, a new suite of next-generation detectors will be needed for the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade of at the Thomas Jefferson National Accelerator Facility (TJNAF), a future facility for rare isotope beams (FRIB) at Michigan State University, other radioactive beam facilities being developed globally, the underground laboratory proposed by the National Science Foundation, DUSEL, the ongoing luminosity upgrade at the Relativistic Heavy Ion Collider (RHIC), and a possible future electron-ion collider. Also of interest is technology related to future experiments in fundamental symmetries, such as neutrinoless double-beta decay experiments and the measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detections are essential. 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. Lastly, this topic seeks new and improved techniques and instrumentation to cope with the anticipated high radiation environment for FRIB. 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 (1) photosensitive devices such as avalanche photodiodes, hybrid photomultiplier devices, single and multiple anode photomultiplier tubes, silicon-based photomultipliers, high-intensity ($\sim 10^{20}$ /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; (2) detectors utilizing photocathodes for Cherenkov and ultra-violet (UV) light detection, and new types of large-area photo-emissive materials such as solid, liquid, or gas photocathodes; (3) liquid argon and xenon ionization chambers and other cryogenic detectors; (4) single-atom detectors using laser techniques and electromagnetic traps; (5) particle polarization detectors; (6) electromagnetic and hadronic calorimeters, including high energy neutron detectors; and (7) 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 particle identification detectors, grant applications are sought for the development of: (1) cost-effective, large-area, high-quality Cherenkov materials; (2) cost-effective, 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 with 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.

Grant applications also are sought for the development of tilted solenoids for spectrometers. In high field devices, iron has the undesirable property that saturation effects change the field characteristics as a function of induction. However, without iron, the stray fields are very often unacceptably high. For superconducting solenoids this problem can be solved by active shielding. The development of magnet systems with tilted crossed solenoid windings and active shielding could provide a solution for a broad variety of ironless superconducting dipoles, which, for example, could be used in high-acceptance spectrometers like the ISLA spectrometer planned for FRIB. Interested parties should contact Dr. Daniel Bazin, NSCL/MSU (bazin@nscl.msu.edu).

Finally, grant applications are sought for innovative designs of high-resolution particle separators needed for a spectrometer research program associated with next-generation rare isotope beam facilities. 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. Position Sensitive Charge Particle and Gamma Ray Tracking Devices— Nuclear physics research has a need for devices to 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 tracking devices such as highly-segmented coaxial and planar germanium detectors; silicon drift, strip, and pixel detectors; and silicon 3D devices. With respect to solid state tracking devices, approaches of interest include (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; (6) and other solid state detectors described in (2)-(4); and (7) techniques for substantial cost reduction of large-mass Ge detectors.

Grant applications also are sought to develop micro-channel plates; and gas-filled tracking detectors such as proportional, drift, streamer, microstrip, Gas Electron Multipliers (GEMs), Micromegas and other types of micropattern detectors, straw drift tube detectors.

Grant applications also are sought to develop position-sensitive charged particle and photon tracking devices, as well as associated technology for these devices, including (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.

Finally, grant applications are sought to develop high-rate, position sensitive beam detectors. Future rare isotope beam facilities like FRIB will provide beams with unprecedented intensity, creating a challenge for single particle tracking and beam profile measurements. The development of position sensitive fast particle detectors for particle tracking and direct/indirect beam profile measurement techniques with high rate capability would be desirable. Ideally these detectors also would be radiation resistant. Interested parties should contact Dr. Marc Hausmann, NSCL/MSU (Hausmann@nscl.msu.edu).

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

c. Technology for Rare Particle Detection—Grant applications are sought for particle detectors and techniques that are capable of measuring very weak, very 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 components (high-density signal cabling, signal and high voltage interconnects, vacuum feedthroughs, front-end amplifier FET assemblies), in order 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.

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

d. Large Band Gap Semiconductors, New Bright Scintillators, Calorimeters, and Optical Elements—Nuclear physics research has a need for developing cost effective new detector and scintillation material with high light outputs and shorter decay times relative to NaI and CsI for manufacturing practical devices to detect charge particles and gamma rays. Therefore, grant applications are sought to develop new materials or advancements for photon detection, including (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)

e. 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); and (7) very thin windows for gaseous detectors, in order 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.

Finally, 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 range of hours, to be used off-line in both neutron-induced and charged-particle-induced experiments.

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

f. Technology for High Radiation environment of Rare Isotope Beam Facility—The establishment of next generation rare isotope beam facilities requires new and improved techniques, instrumentations and strategies to deal with the anticipated high radiation environment in the production, stripping and transport of ion beams. Therefore grant applications are sought to develop:

(1) Rotating vacuum seals for application in high-radiation environment: Vacuum rotary feedthroughs for high rotational speeds,which have a long lifetime under a high-radiation environment, are highly desirable for the realization of rotating targets and beam dumps for rare isotope beam production and beam strippers in high-power heavy-ion accelerators. Interested parties should contact Dr. Wolfgang Mittig, NSCL/MSU (mittig@nscl.msu.edu).

(2) Radiation resistant multiple-use vacuum seals**:** Elastomer-based multi-use vacuum seals have a limited lifetime due to radiation damage in the high-radiation environment found in the target facility of FRIB and other high-power target facilities. Alternative solutions that provide extended lifetimes and are suitable for remote-handling applications are needed. Interest parties should contact Tom Burgess, SNS/ORNL (Burgesstwg@ornl.gov).

(3) Radiation resistant magnetic field probes based on new technologies: An issue in all high-power target facilities and accelerators is the limited lifetime of conventional nuclear magnetic resonance probes in high-radiation environments. The development of radiation-resistant magnetic field probes (possibly based on new techniques like ion traps) for 0.2-5 Tesla and a

precision of dB/B<1E-4 would be highly desirable. Interested parties should contact Dr. Georg Bollen, FRIB/MSU (bollen@frib.msu.edu).

(4) Techniques to study radiation transport in beam production systems: The use of energetic and high-power heavy ion beams at future research facilities will create significant radiation fields. Radiation transport studies are needed to design and operate facilities efficiently and safely. Further improvements to radiation transport codes and models of secondary radiation production, shielding, and heat deposition – along with their validation against experimental data – are necessary. Heavy ion transport calculations in general take significantly longer computational time than for light ion transport. Therefore, improvements in calculation efficiencies are needed. Currently available heavy ion transport codes do not account for the production and intensity of the ions, or for changes in charge-state distributions as the ions pass through matter or magnetic fields. The development and incorporation of charge-state distribution models into radiation transport codes would enhance both the design of beam stripping and beam absorption components and the safety and lifetime consequences of produced radiation fields. Interested parties should contact Dr. Reg Ronningen, NSCL/MSU (ronningen@nscl.msu.edu).

(5) Techniques for modeling radiation damage with heavy ions: The use of energetic and high-power heavy ion beams at future research facilities will create significant levels of radiation damage to facility components, thus limiting their useful lifetimes. Sparse experimental data taken at low energies indicate that the radiation damage caused by heavy ions may be orders of magnitude higher than that predicted by existing models, such as those currently implemented in radiation transport codes. It is purported that phenomena such as the Swift Heavy Ion effect, which are not accounted for, may be important. New and/or improved models are needed to reliably estimate the effects of radiation damage by heavy ions, in order to better design and optimize the performance of future facilities. Interested parties should contact Dr. Reg Ronningen, NSCL/MSU (ronningen@nscl.msu.edu).

(6) Techniques for thermal studies of targets, beam absorbers, strippers: High intensities of heavy ion beams for rare isotope beam production will result in a significant energy density deposited in facility components such as production targets, beam absorbers, and beam strippers. The anticipated levels of energy density will require sophisticated designs for these components, in order to ensure the integrity and operability for extended periods of time. Efforts are needed to calculate energy deposition and to perform thermal and stress analyses. Interested parties should contact Dr. Reg Ronningen, NSCL/MSU (ronningen@nscl.msu.edu).

(7) Beam optics simulation tools for fragment separators: Fragment separators are complex devices at the heart of several existing and planned rare isotope research facilities, and the capabilities of next generation fragment separators will be a challenge to existing simulation software. New, fast and accurate simulation tools could speed the planning of such devices and enable related experiments to be performed faster and more efficiently. Interested parties should contact Dr. Marc Hausmann, NSCL/MSU (Hausmann@nscl.msu.edu).

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

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47. NUCLEAR PHYSICS ISOTOPE SCIENCE AND TECHNOLOGY

In FY09 the Isotope Program transferred from the Office of Nuclear Energy to the Office of Nuclear Physics in the Office of Science. Stable and radioactive isotopes are critical to serve the broad needs of our modern society and are critical to scientific research in chemistry, physics, energy, environment, material sciences and for a variety of applications in industry and national security. A primary goal of the Department of Energy's Isotope Development and Production for Research and Applications Program (Isotope Program) within the Office of Nuclear Physics (NP) is to support research and development of methods and technologies in support of the production of isotopes used for research and applications that fall within the Isotope Program portfolio. The Isotope Program produces isotopes that are in short supply in the U.S. and of which there exists no domestic commercial production capability; some exceptions include special nuclear materials and molybdenum-99, for which the National Nuclear Security Administration has responsibility. The benefit of a viable research and development program includes an increased portfolio of isotope products, more cost-effective and efficient production technologies, a more reliable supply of isotopes year-around and the reduced dependence of foreign supplies. With the successful development of advanced production technologies more isotopes can be produced and distributed for research and applications. Additional guidance for research isotope priorities is provided in the Nuclear Science Advisory Committee Isotopes (NSACI) report available at (http://www.sc.doe.gov/np/nsac/nsac.html). Priorities for research isotope production are articulated in this report which will serve to guide production plans of the Isotope Program.

a. Novel or improved production techniques for radioisotopes or stable isotopes
Research should focus on the development of advanced, cost-effective and efficient technologies for producing isotopes that are needed by the research and applied communities. The successful research grants should lead to breakthroughs that will facilitate an increased supply of isotopes that complement the existing portfolio of isotopes produced and distributed by the Isotope Program.

Grant applications are sought for new technologies to produce large quantities of separated isotopes – such as kg quantities of Germanium-76 (^{76}Ge), Selenum-82 (^{82}Se), Tellurium-130 (^{130}Te), Xenon-136 (^{136}Xe) – and other materials that are needed for rare particle and rare decay searches in nuclear physics research. Further guidance for research isotope priorities is provided in the Nuclear Science Advisory Committee Isotopes (NSACI) report available at (http://www.sc.doe.gov/np/nsac/nsac.html).

Interested parties may contact Wolfgang Runde at runde@lanl.gov.

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

b. Improved radiochemical separation methods for preparing high-purity radioisotopes
Separation of isotopes from contaminants and bulk material and the purification of the isotope to customer specifications is a critical process in the production cycle of an isotope. Most of the processes developed to date rely on old technologies and still require extensive manpower to operate specialized equipment, such as manipulators for remote handling in hot cell

environments. Conventional separation methods may include liquid-liquid extraction, column extraction, distillation or precipitation and are used to separate radioactive and non-radioactive trace metals from target materials, lanthanides, alkaline and alkaline earth metals, halogens, or organic materials. High-purity isotope products are essential for high-yield protein radiolabeling, for radiopharmaceutical use, or to replace materials with undesirable radioactive emissions. Improved radiochemical separation methods can be achieved and costs of isotope production can be reduced by a) improvements in separations chemistry methods, and b) implementing automated systems and robotics. Of particular interest are developments that automate routine separation processes in order to reduce operator labor hours and worker radiation dose, including (semi)automation modules for separations or automated, micro-processor controlled systems for elution, radiolabeling, purification, and dispensing.

Applications are sought for innovative developments and advances in separation technologies to reduce processing time, to improve separations efficiencies, to automate separation systems, to minimize waste streams, and to develop advanced materials for high-purity radiochemical separations. In particular, the Department seeks improvements in (1) lanthanide and actinide separations, (2) in the development of higher binding capacity resins and adsorbents for radioisotope separations to decrease void volume and to increase activity concentrations, (3) the scale-up of separation methods demonstrated on a small scale to large-volume production level, and (4) new resin and adsorbant materials with increased resistance to radiation.

The following are some examples for advanced chemical separation technology needs. In lanthanide radiochemistry, improvements are sought to a) prepare high-purity samarium-153 by removing contaminant promethium and europium; or b) to prepare high-purity gadolinium-148 and gadolinium-153 by ultra-pure separation from europium, samarium, and promethium contaminants. In actinide radiochemistry, innovative methods are sought a) to improve radiochemical separations of or lower-cost approaches for producing high-purity actinium-225 and actinium-227 from contaminant metals, including thorium, radium, lead, and/or bismuth; or b) to improve ion-exchange column materials needed for generating lead-212 from radium-224, and bismuth-213 from actinium-225 or radium-225. The new technologies must be applicable in extreme radiation fields that are characteristic of chemical processing involving high levels of alpha-and/or beta-/gamma-emitting radionuclides.

Interested parties May contact Dr. Russ Knapp (knappffjr@ornl.gov).

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

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48. SITE REMEDIATION AND DEACTIVATION & DECOMMISSIONING IN THE DOE COMPLEX

DOE is responsible for site remediation and deactivation and decommissioning (D&D) of facilities in the DOE complex. With respect to these activities, this topic addresses three particular areas of concern:

- The need to validate the performance of remediation activities over time. New or improved technologies are needed to monitor the long-term performance of the remedies and to provide information that will validate whether the remedies continue to be effective.

- The need to reduce risks to workers from potential exposures associated with decontamination and decommissioning activities. Workers are required to wear personnel protective equipment to protect them from exposure to hazardous contaminants, such as radionuclides, metals such as mercury, lead, asbestos, and organics. The DOE is interested in new or improved personnel protective clothing or equipment that not only is protective against the contaminants but also is waterproof.

- The needs to decontaminate and dispose of hundreds of miles of contaminated piping, during both site remediation and D&D activities. In particular, the DOE is interested in the development of technology to shred contaminated piping and systems and to separate metallic and non-metallic materials, while also ensuring the protection of workers and the environment.

Grant applications are sought only in the following subtopics:

a. Technologies for *In Situ* Measurements of Geochemical, Biogeochemical, and Microbial Processes in the Subsurface—Cost-effective, long-term technologies must be developed and deployed to monitor closure sites or areas of sites where remediation has been completed. The monitoring – of soil, groundwater, and surface water – is needed to validate cleanup performance and provide information to ensure that the remedies continue to be effective and protective of the environment. The hazardous constituents or contaminants that require monitoring include organics, metals, and radionuclides. Grant applications are sought to develop the following innovative technology solutions:

- S*patially integrated monitoring tools* that will focus on documenting plume stability and/or natural attenuation, as well as providing a physical assessment of potential problems (e.g., subsidence in isolated waste). Approaches of interest may include meteorological data and satellite imagery (to document boundary conditions and to specifically measure the driving forces for plume migration), a permanent geophysical survey system using emplaced electrodes, ecosystem monitoring, push pull methods, etc.

- O*nsite and field monitoring tools and sensors* that will reduce laboratory-based analytical costs. Approaches of interest may include field analysis sensors, deployed sensors, screening tools, and other concepts to reduce the number of laboratory-based analyses or to reduce sampling costs (e.g., reduce investigation derived waste). Proposed approaches must demonstrate substantial improvements over the current state of the art. The following radionuclides are of interest: technetium, chromium, strontium, mercury, uranium, plutonium, americium, cesium, and cobalt, in addition to chlorinated solvent plumes.

Of particular interest are proposed approaches that offer the potential to monitor multiple hazardous constituents at the clean up levels of the sites.

b. New or Improved Waterproof Personnel Protective Clothing/Equipment (PPC/PPE)— Many of the nuclear facilities contaminated with radionuclides and other hazardous materials such as asbestoses, lead, mercury, beryllium, and organic solvents are undergoing D&D. Workers performing tasks in areas contaminated with radioactive material are required to wear personal protective clothing/equipment (PPC/PPE). These workers often must operate in facilities that are in a deteriorated physical condition, where rainwater has infiltrated the structures. In fact, in some facilities, such as K-25 and other buildings at the Oak Ridge site, several inches of rainwater has accumulated. Unfortunately, currently available waterproof PPC/PPE are heavy and cause heat stress to workers. Therefore, grant applications are sought to develop lightweight, waterproof PPC/PPE that will result in safer working conditions, improved worker comfort (such as allowing one way escape of perspiration), and reduced the risks of heat stress.

The lightweight PPC/PPE waterproof fabric should have the following characteristics: (1) flexibility in areas such as elbows, knees, and wrists; (2) tear resistance; (3) a thickness of 18-25 mils; and (4) cost effectiveness. In addition, the fabric must be well suited for nuclear or hazardous material dismantlement activities, where the work may be performed in an open air environment and/or in enclosed facilities. In such environments, liquid line breaks may occur, and degraded roofing systems may not provide adequate protection.

c. New or Improved Mechanical Shredding Equipment for Piping—EM facilities and sites have significant quantities of piping that has been contaminated with hazardous materials, including radionuclides. These facilities include such buildings as K-25 canyon facilities at the Savannah River Site and Hanford. Although the piping may be decontaminated, residual quantities of radioactive waste may still remain. Shredding the radioactively contaminated components of the metallic piping systems will reduce the amount of waste generated during nuclear facility decommissioning. Therefore, grant applications are sought to develop new designs for mechanical shredders that can handle various nuclear waste streams –i.e., Low Level Waste (LLW), High Level Waste (HLW), and Transuranic Waste (TRU Waste) – and prevent criticality conditions from occurring. The mechanical shredder should have the ability to separate metallic and non-metallic waste, and be able to shred contaminated piping up to four inches in outside diameter. In addition, the capability to shred and separate contaminated piping should (1) result in a volumetric reduction on contaminated waste generated, leading to disposal cost savings; and (2) be protective of workers and environment.

d. New or Improved Technologies to Stabilize Friable Asbestos for Deactivation and Decommissioning Activities—Facilities throughout the Department of Energy Complex contain several miles of asbestos wrapped piping that needs to be abated. Piping can range in diameter from 1.5 inches to 36 inches and the thickness of the asbestos insulation can range from 0.5-inch to 12 inches. Current methods for removal of asbestos insulation involve workers in personal protective equipment and respirators manual cutting and removing the insulation. This can produce significant airborne asbestos contamination creating a potential environmental and worker exposure risk. Grant applications are sought to develop a fixative or stabilizing agent that can be applied to and penetrate friable asbestos containing materials and make it non-friable or less potentially friable. The fixative or stabilizing agent should be non-toxic, non-carcinogenic, non-flammable, non-explosive, non-leachable, non-corrosive, and not reconstitute as a liquid over time. The fixative or stabilizing agent cannot contain any Resource Conservation and Recovery Act (RCRA) hazardous constituents and cannot produce a waste form unsuitable for disposal at on-site and commercial disposal facilities. Application of the fixative or stabilizing agent to the contaminated piping should be made using standard commercial equipment and processes.

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49. REMOTE SENSING

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

a. Radiological Material Isotopic Attribution Sensor—Advanced sensors are needed to provide rapid forensics of radiological materials in the event of a nuclear attack. The isotope content and ratios of these materials, as well as various impurities in the samples, are critical for forensics, since they provide clues on where the material was produced or mined. Therefore, grant applications are sought to develop a standoff-capable technology that can be operated remotely (with a goal of 150 – 250 m) to rapidly determine the isotopic ratio of uranium or other actinides, and elemental composition of target materials. An integrated sensor should measure key isotopic ratios and elemental composition in condensed samples. The sensor should operate on-site and in real time, with spatial resolution ~1 mm. One possible analytical technique is laser-induced breakdown spectroscopy (LIBS), which is emerging as a universal standoff detection method that also has been demonstrated to resolve the isotopes of heavy elements.

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

b. Temperature/Emissivity Separation in Simple Geometries—Hyperspectral sensors are used for the imagery of target objects. From this imagery, it is a challenge to determine both the temperature of the target object and its thermal spectral emissivity, even in conditions where both the sky and surface are uniform. Therefore, grant applications are sought to combine modeling and experiment to develop an accurate data exploitation algorithm that, using hyperspectral imagery taken in a setting where the ground surface is uniform and flat and the sky is clear, can derive the temperature and thermal emissivity of a hard target with a simple geometry. Within the model, target geometries should include horizontal and vertical cylinders, rectangular objects (with significant vertical extent), flat objects on the ground (with negligible vertical extent), as well as spheres and hemispheres. In addition, the model should include natural surfaces such as soil, sand and grass, as well as man-made surfaces such as concrete and asphalt.

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c. Mid-Infrared Transparent Glass with Optical Index, n = 2—Optical retroreflectors find applications in fields as diverse as atmospheric research, optical communications, optical metrology, and remote sensing. Typically, they take the form of corner-cube reflectors or cat's eye reflectors. However, these configurations are not isotropic and suffer from small acceptance angles that limit their effectiveness in remote sensing applications. In contrast, spherical retroreflectors are ideally isotropic and can be capable of extremely large acceptance angles. The simplest solution, therefore, is to create a homogeneous spherical retroreflector having optical index, n = 2, which would provide reasonable retroreflection efficiency in the paraxial regime. Unfortunately, while optical retroreflective materials have been developed for visible applications (S-LAH79), few options are available for mid-infrared applications.

Therefore, grant applications are sought for the development of new glass compositions having good mid-infrared (MWIR) optical transparency (3-12 µm), low dispersion, and a tailorable optical index of approximately n=2, in order to enable the fabrication of miniature spherical retroreflectors for MWIR remote sensing applications. The optical materials must be compatible with low cost mass production (e.g., traditional mechanical sphere fabrication and polishing, or drop tower methods) and must be stable under severe environmental exposure conditions. Approaches of interest could include heavy oxide or telluride glasses. Proposed projects should demonstrate the feasibility of the mass production of miniature spheres (1-8 mm diameter).

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

d. Megapixel Low Light Level Imager for Remote Sensing—Many remote sensing surveillance missions that persist over time require the continuous wide-area observation of roadways, road junctions, and other areas of interest from platforms operating at altitude. In recent experiments, the video from each of (up to) 16 individual cameras were reconstructed into a post processed image effectively representing a large focal plane array (FPA) to form a complete view of a large area of interest. However, a single, monolithic FPA sensor would provide significant advantages – in terms of reduced complexity, size, weight, and power – compared to the current system design.

Therefore, grant applications are sought to develop a large-area, low-light FPA and to scale current fabrication processes to produce a full, wafer-size detector with acceptable quality. Approaches of interest should include the fabrication of a large area. monolithic CMOS focal plane of at least 8K x 8K pixels, with the potential to expand to 16K x 16K pixels, and with the following specifications: (1) pixel size of 5-10 microns, (2) frame rate of 2 - 20 Hertz with sub-array readout capability of no less than 30 Hertz, (3) low noise architecture for dawn-to-dusk operation, (4) provision for both color and black-and-white imagery, and (5) a capability of being manufactured using 200 mm wafer processes.

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

e. Remote Spectroscopic Detection of Nuclear Reaction Byproducts—In order to further the goal of nuclear nonproliferation, it is important to be able to detect remotely signs of clandestine nuclear reactions, such as, but not limited to, the conversion of uranium to plutonium. One current sensing approach is to detect ionizations produced by high energy beta particles that result from the radioactive decay of unstable isotopes. A complementary approach is to detect the stable atoms that are produced simultaneously. One such atom is Rb, which is converted immediately in the presence of moisture into rubidium oxide. Detection of the spectroscopic signatures of these oxides or hydroxides, concurrent with the detection of beta-induced ionization, could serve to improve the confidence level in the identification of the presence of radioactive elements. Therefore, grant applications are sought for the development of technology for the remote detection of byproducts of nuclear reactions via spectroscopy in the microwave and mm-wave regime. One possible approach could involve the illumination of the target area with active radiation, followed by spectral analysis of the backscattered signal.

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

f. Waveguide-Coupled Optical Modulator for W-Band Up-Conversion—Passive millimeter wave imaging provides many advantages in remote sensing, such as the ability to see through clouds, dust, and smoke, as well as daytime/nighttime operation. One atmospheric window that is exploited in millimeter wave imaging is at 94 GHz (W-band). However, a potential drawback with passive millimeter wave imaging is its inherent low resolution compared to optical approaches, such as passive infrared imaging. Therefore, at reasonable standoff distances, sub-pixel detection methods, or exploitation of mixed pixel data, become essential. One approach to extracting additional information is the use of millimeter wave polarimetry. However, this approach requires the polarization signals to be combined coherently, which can cause the very sensitive components used in CMB (Waveguide-coupled optical Modulator for W-band) research to suffer significant waveguide loss in signal routing. This drawback can be alleviated by optical up-conversion, while still preserving the amplitude and phase relationship of multiple signals. Moreover, optical up-conversion would provide other benefits: (1) it would enable advances in optical components, which result from the telecomm build-out, to be leveraged; and (2) it would permit remote operation of two or more receivers in a phased array, in order to increase imaging resolution. Unfortunately, no commercial full-band W-band (75-110 GHz) modulators exist presently, although research suggests steady improvement in the fabrication of research devices. Therefore, to advance instrument development in passive millimeter wave imaging for remote sensing applications, grant applications are sought for the design and fabrication of a low-insertion-loss W-band modulator having a mm-wave insertion loss of < 2.5 dB and an optical insertion loss of < 3 dB.

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

g. Time History of Optical Emissions—Grant applications are sought for ground-based systems that can detect and record the time history of optical emissions from a nuclear detonation (NuDet) in the atmosphere within 1 km of the surface. The eventual goal of such a system is to augment the capabilities currently implemented on space platforms. Proposed systems, which should consist of low-cost sensor and processing components, must be able to identify NuDet yields of 20 Kt (See Figure 2.123, p. 69 in Glasstone and Dolan,1977) and below, measured during both day and night within an environment that includes signals from natural and anthropogenic sources. The sensor system should permit economical balancing between (1) networks with widely-distributed but inexpensive sensing, reporting, and processing capability; and (2) more elaborate and expensive point-specific capabilities. A desirable feature of the sensor package is the eventual ability to employ the sensors on space-based platforms. Grant applications should propose an architecture that provides candidate sensor, recording, and processing nodes; acquires background measurements; and demonstrates potential signal discrimination.

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50. RADIATION DETECTION

The Office of Nuclear Nonproliferation Research and Development (NA-22) is focused on enabling the development of next generation technical capabilities for radiation detection of nuclear proliferation activities. As such, the office is interested in the development of radiation detection techniques and sensors, and advanced detection materials, that address the detection and isotope identification of unshielded and shielded special nuclear materials, and other radioactive materials in all environments. In responding to these challenging requirements, recent research and development has resulted in the emergence of radiation detection materials that have high-energy resolution. From these materials, the development of radiation detectors -- which are rugged, reliable, low power, and capable of high confidence radioisotope identification – are sought. Currently, the program is focused on the development of improved capabilities for both scintillator- and semiconductor-based radiation detectors. The objective of this topic is to gain insight into a mechanistic understanding of material performance as the base component of radiation detectors. That is, the program is interested in moving beyond the largely empirical approach of discovering and improving detector materials to one based on a clear understanding of basic materials properties. **Grant applications are sought only in the following subtopics:**

a. Growth of Radiation Detection Materials—Grant applications are sought to improve the growth of radiation detection materials, especially in any of the following three areas:

1) **Thermal Neutron Detection Materials -** New materials for the detection of thermal neutrons are sought. The most desirable materials would utilize elements – such as ^{6}Li, ^{10}B, ^{157}Gd, ^{113}Cd, or ^{199}Hg – that detect neutrons directly, but any materials with high intrinsic efficiency will be considered. Phase I must address the identification of such materials and a plausible method for producing the material at reasonable cost. Phase II must involve the growth of these materials, demonstration of charge transport properties, and the measurement of neutron detection efficiencies.

2) **Improvements to Semiconductor Growth -** In this call, we are interested in promoting the industrial capacity to develop large volume, high quality radiation detector materials based on semiconductors. As an example, in the last three years, pixilated cadmium zinc telluride (CZT) detectors using depth correction have demonstrated resolution at room temperature (0.5% at 662 keV) that rivals high purity germanium (HPGe). Approaches of interest must address growth issues involving such semiconductor materials, so that reliable, high yield, rapid, and large volume growth is readily achievable. Phase I should result in the identification of a clear path to improving upon existing growth techniques. Phase II should include a demonstration of a material fabrication process that is free from dislocations, cracking, chemical heterogeneities, and minor crystalline phase impurities, including precipitates.

3) **Polycrystalline Scintillators -** As an alternative to crystal growth, techniques that produce high quality, large volume scintillators with good spectroscopic performance from the consolidation of powders are highly desirable. Although most previous work has been done with oxide compounds, polycrystalline halide scintillators – formed from the new alkaline earth halides, the elpasolites, and other materials that demonstrate high performance in single-crystal form – would be of particular interest. A laboratory demonstration is expected in Phase I, while Phase II should lead to the development of a commercial process with a factor-of-10 cost advantage over current crystal growth techniques.

Questions Contact: David Beach, david.beach@nnsa.doe.gov or
Robert Runkle, robert.runkle@nnsa.doe.gov

b. Radiation Detector Development—Grant applications are sought to improve radiation detector development, especially in any of the following areas:

1) **Thermal Neutron Detection Systems -** Large-area neutron detectors that are not reliant on ^{3}He are of interest for a variety of nonproliferation and safeguard applications. Of particular interest are novel detection system concepts that are scalable to 1 m^{2}, have a detection efficiency

of more than 50% for thermal neutrons, are capable of better than microsecond timing of neutron events, and have a gamma rejection ratio of better than 1 in 10^5. Phase I should develop a clear system design with a quantitative assessment of the performance that would be achieved with this instrument. In Phase II, the system should be ruggedized and made transportable.

2) **Next-generation, Scintillator-Based Handheld Radioisotope Identifier -** Current scintillator-based radioisotope identifiers that use sodium iodide often do not perform well in a number of nonproliferation and safeguard applications. Although newer identifiers based on lanthanum bromide generally perform better, they are much more expensive and their performance at lower energies is actually inferior to sodium iodide. Recently, several new compounds have been identified that not only have a resolution comparable to lanthanum bromide, but also have improved proportionality and the potential for much lower cost. Thus, grant applications are sought to utilize these new materials to produce a next generation isotope identifier. In addition, it is highly desirable that proposed identifiers (1) utilize a solid-state alternative to a photomultiplier tube, and (2) contain sufficient computational power to allow a sophisticated, high confidence, isotope identification algorithm. Phase I should develop a clear system design with a quantitative assessment of the performance that would be achieved with this instrument. Phase 2 should involve the construction of a prototype instrument.

Questions Contact: David Beach, david.beach@nnsa.doe.gov or
Robert Runkle, robert.runkle@nnsa.doe.gov

REFERENCES:

1. A.J. Peurrung. "Recent Developments in Neutron Detection", Nuclear Instruments and Methods in Physics Research A, Vol. 443, Issue. 2-3, pp. 400-415 (2000). (ISSN: 0168-9002) (Full text available at: http://www.sciencedirect.com/science/journal/01689002)

2. J.K Shultis and D.S. McGregor. "Efficiencies of Coated and Perforated Semiconductor Neutron Detectors", IEEE Transactions on Nuclear Science, Vol. 53, Issue 3, Part 3, pp. 1659-1655 (2006). (Full text available at: http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=34478&isYear=2006&count=70&page=2&ResultStart=50)

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51. GLOBAL NUCLEAR SAFEGUARDS R&D

The Global Nuclear Safeguards Program supports NNSA's nuclear nonproliferation mission by developing innovative safeguards technologies to enhance verification of nuclear materials and activities. The program develops technologies to detect diversion of nuclear material from declared facilities; to detect undeclared nuclear material and activities; and to verify compliance with arms control treaties and agreements related to the control, production, or processing of nuclear material. The program includes R&D in nuclear (and relevant nonnuclear) measurements; information integration, and management; advanced tools for systems analysis; authentication, and containment, and surveillance. **Grant applications are sought only in the following subtopics:**

a. Tags and Seals—Grant applications are sought to develop innovative tag and seal technologies to detect the diversion of nuclear material and to verify compliance with treaties and agreements related to its control, production, or processing. Approaches of interest include (1) passive and active tags and seals for identifying and securing safeguarded items, and (2) passive and active tags and seals to ensure continuity of knowledge (COK) during material transfers (e.g., COK of UF_6 cylinders). For field applications, desired system features include low-cost, high-confidence, durability, and small size. Grant applications that propose innovative technologies for power reduction, secure communication, authentication, and tamper indication are welcome.

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

b. Safeguards Measurement Sensors—Grant applications are sought to develop technologies to enable the dramatic improvement of safeguards measurements, both nuclear and nonnuclear. Technologies of interest include (1) an enabling technology for sensor survivability in high radiation environments, (2) an enabling technology to reduce power requirements for remote monitoring, (3) enabling manufacturing techniques for innovative radiation sensors, (4) enabling information-processing techniques for multiplexed sensors or for the integration of large datasets. Grant applications must show a clear link between the proposed technology and the improvement in safeguards measurements.

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

REFERENCES:

1. "Safeguards to Prevent Nuclear Proliferation", March 2009. (Full text available at: http://www.world-nuclear.org/info/inf12.html)

2. "The US Support Program to IAEA Safeguards", Modified June 5, 2008. (URL: http://www.bnl.gov/ISPO/ussp.asp)

3. Safeguards R&D Program in the United States presented at the 50th Anniversary meeting of Institute for Nuclear Materials Management, July 2008

52. 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, the SAM Program provides research and development support to 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 also assesses the utility of social, political, and economic models, to aid in the detection of potential nuclear proliferation activities. **Grant applications are sought only in the following subtopics:**

a. Proliferation History and Knowledge Base Visual Design—Grant applications are sought to develop innovations in the visual representation of proliferation concepts and their historical evolution, along with references and data, as compiled by DOE experts, resulting in a unique and original web-based presentation. Ultimately, the resulting product should help personnel involved in the development of models and simulations. Criteria for acceptance include (1) ease and clarity of information assimilation, and (2) a comprehensive and pedagogical treatment of the subject matter. The resulting product will be displayed on the Office of Nonproliferation Research and Development‘s website for Simulations, Algorithms, and Modeling, and will be made accessible to a wide variety of personnel at the national laboratories and the Department of Energy.

Questions Contact: Alexander Slepoy, alexander.slepoy@nnsa.doe.gov

b. Radiation Detection Scenario Simulator—By combining the best attributes of Monte Carlo and deterministic approaches, neutron and gamma-ray radiation transport methods could be improved significantly (in terms of computational time and accuracy), thereby addressing a wide range of national security scenarios. These hybrid methods could take several forms (e.g., separate but coupled calculations, or the use of the deterministic adjoint solution to calculate weight windows for Monte Carlo calculations), each having advantages for specific problems. Therefore, grant applications are sought to develop a software package, based on hybrid neutron and gamma-ray transport methods, for use by a radiation detection analyst in support of a range of radiation detection applications – including viability studies, comparative evaluations of present and future technologies, and design optimization studies. Approaches of interest should produce a software package with the following key capabilities:

- Integrated algorithms to define a wide range of gamma-ray and neutron source terms (e.g. weapons-grade Pu aged to 20 years)
- Flexible edit/tally options for scalar flux, angular flux and detector response functions
- Detector response calculations that can support a wide range of neutron and gamma-ray sensors (e.g. high-resolution gamma-ray spectrometers, moderated neutron counters)
- User-friendly interface tailored to detection analysts, not transport-method experts

Questions Contact: Alexander Slepoy, alexander.slepoy@nnsa.doe.gov

c. Data Processing Toolbox—Grant applications are sought to develop an end-to-end toolbox that will significantly improve and streamline data processing and information extraction in support of the proliferation detection mission. The technical requirements are summarized as follows:

1) **Signal Processing** - The toolbox should apply modern signal processing theory and methods to extract salient features from raw data.

2) **Anomaly Detection** - The toolbox is expected to use its salient features to characterize and identify anomalous events.

3) **Data Fusion** - The system should apply appropriate data fusion algorithms, if necessary, to expand information completeness, improve its confidence, and even produce the new information that is not seen in a single sensor or single type of sensors.

4) **Data Storage** - The raw data must be stored at the collection site for certain time; the data can be either transferred to a remote data center or queried from a remote site.

5) **Verification and Validation** - The toolbox must be rigorously verified and validated on a demonstration system, in order to ensure its fidelity and utility.

Applicants are encouraged to discuss how they will design and quantify system performance using objective measures, including, but not limited to, detection rate, false positive rate, confidence level, computational complexity, computing efficiency, and general applicability. The end product, the toolbox, is expected to be easily adapted to real applications by the user community.

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

REFERENCES:

1. Nuclear Explosion Monitoring Research and Engineering Program Strategic Plan, National Nuclear Security Administration, September 2004. (Document No. DOE/NNSA/NA-22-NEMRE-2004) (Full text available at: https://na22.nnsa.doe.gov/cgi-bin/prod/nemre/index.cgi?Page=Strategic+Plan)

2. U.S. National Data Center, Air Force Technical Applications Center. (URL: http://www.tt.aftac.gov/toppage.html)

3. Annual Research Review Proceedings for Ground-Based Nuclear Explosion Monitoring Research and Engineering, sponsored by the National Nuclear Security Administration and the Air Force Research Laboratory. (Available at: https://na22.nnsa.doe.gov/cgi-bin/prod/researchreview/index.cgi)

53. RESEARCH TO SUPPORT NUCLEAR EXPLOSION MONITORING

The Ground-based Nuclear Explosion Monitoring Research and Development (GNEM R&D) Program in the Office of Nuclear Detonation is sponsored by the U.S. Department of Energy's

National Nuclear Security Administration’s Office of Nonproliferation Research and Development. This program is responsible for the research and development necessary to provide the U.S. Government with capabilities for monitoring nuclear explosions. The mission of the GNEM R&D Program is to develop, demonstrate, and deliver advanced ground-based seismic, radionuclide, hydroacoustic, and infrasound technologies and systems to operational agencies to fulfill U.S. monitoring requirements and policies for detecting, locating, and identifying nuclear explosions (see Reference 1). Within the context of one or more of these technologies, research is sought to develop algorithms, hardware, and software for improved event detection, location, and identification at thresholds and confidence levels that meet U.S. requirements in a cost-effective manner. Superior technologies will help improve the Air Force Technical Applications Center’s (Reference 2) ability to monitor for nuclear explosions, which are banned by several treaties and moratoria. Annual research progress of the GNEM R&D program is available in proceedings posted on-line (see Reference 3).

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

a. Waveform Communication Technology—Grant applications are sought to develop very inexpensive (<$1,000) and light weight (<1 lb) automated devices that would measure and transmit key mining and industrial blast explosion seismic and/or infrasound information to agencies and industries (both within the U.S. and abroad). Explosions of interest include large scale mining and industrial blasts (magnitude >2.5) and key parameters are event origin, magnitude, and location. Ideally, these key parameters would be computed insitu and transmitted, but schemes that transmit raw data with subsequent determination of these parameters externally also will be considered. Specifically, these devices would detect and record close-in (< 5km) large mining and industrial explosion origin time (within 0.1 sec), location (within 1 km), and size (within 0.3 magnitude units). This “Ground truth” (GT) event detector, shall operate automatically, i.e., without any human intervention. Such devices should be small enough to be able to be shipped easily and inexpensively to remote locations, with quick, uncomplicated and trouble-free start-up, able to operate autonomously for a significant period of time (>6 months), detect, store and transmit many GT events (hundreds of events) and inexpensive enough to be discarded after the batteries die.

Grant applications are also sought that provide unique communication systems for temporary ocean bottom seismometers and hydrophone monitoring systems that allow for remote system status interrogation and retrieval of selected data segments from in situ hydrophones. The deployment of temporary ocean bottom seismometers and hydrophone monitoring systems is costly and unpredictable and unpredictable because data quality is usually not known until the end of the experiment when the equipment is retrieved.

Questions - Contact: Leslie Casey, leslie.casey@nnsa.doe.gov

b. Measurement of Xe Background, Transport, and Fate—Grant applications are sought to measure, estimate, or model local and worldwide xenon (Xe) backgrounds to further the technical development of xenon as a signature of underground nuclear explosions. In addition to nuclear explosions as a source of Xe, commercial, medical, and reactor operations should be considered as alternate sources. Thus approaches of interest that couple actual ground truth measurements with the fate, leakage, and transport of Xe from these sources are highly desired.

Grant applications also are sought to (1) better understand and mitigate the retention of noble gases on plastic scintillators used in radioactive xenon measurement systems, and (2) improve gas transfer and gas separation in these systems. Gas transfer and separation components of interest include small, gas-tight, oil-less compressors; vacuum pumps; and gas transfer syringes:

- Compressors should be capable of 40 liters per minute continuous flow at 80-100 psig, hermitically sealed, and oil free, and should operate on 120 VAC.
- Similarly, transfer pumps should be small and gas-tight, and should achieve a good ultimate vacuum (<0.1 Torr) while also compressing the output to 60-80 psig.
- For relatively small volume transfers (<1 standard liter of gas per cycle), transfer pumps may be in the form of a syringe-style pump or some other continuous-duty mechanical design.

Optimal factors for these components include gas-tightness, durability, operation at 120 VAC or DC power, and the ability to be contamination free.

Questions - Contact: Leslie Casey, leslie.casey@nnsa.doe.gov

REFERENCES:

1. Nuclear Explosion Monitoring Research and Engineering Program Strategic Plan, National Nuclear Security Administration, September 2004. (Document No. DOE/NNSA/NA-22-NEMRE-2004) (Full text available at https://na22.nnsa.doe.gov/cgi-bin/prod/nemre/index.cgi?Page=Strategic+Plan)

2. U.S. National Data Center, Air Force Technical Applications Center, http://www.tt.aftac.gov/toppage.html

3. Annual Research Review Proceedings for Ground-Based Nuclear Explosion Monitoring Research and Engineering, sponsored by the National Nuclear Security Administration and the Air Force Research Laboratory. (Available at: https://www.na22.doe.gov/cgi-bin/prod/researchreview/index.cgi?Page=Proceedings)

54. NUCLEAR FORENSICS

The Nuclear Forensic Research and Development Program in the Office of Nuclear Detonation is sponsored by the U.S. Department of Energy's National Nuclear Security Administration's Office of Nonproliferation Research and Development. This program supports next-generation R&D to provide timely, accurate, discriminating, and robust technical answers to forensics-related questions associated with a post-detonation or interdicted device event (e.g., questions about a detonated nuclear device's composition, characteristics, and design features with respect to its pre-detonated state and its detonation performance). The emphasis is on the underlying science, in order to advance and enhance the current U.S.Government's nuclear forensics capability. **Grant applications are sought only in the following subtopic:**

a. Codes for Radiation Transport and Particle Scattering in Urban Settings—Grant applications are sought to create a calculation tool for modeling the relevant and predominant physics that govern the interactions of gamma rays (with energies between 5 keV and 20 MeV) and neutrons (with energies between 10^{-2} eV and 20 MeV) with structures and materials in urban environments. The desired capability should include the modeling of gamma-ray and neutron radiation transport, including scattering and energy loss effects. The tool should allow the user to input specific spectral distributions of gamma and neutron energies that originate as an intense pulse from a particular point source location within a city. The initial spectral density profile (intensity as a function of energy and time) of the gamma and neutron radiation and the originating location are degrees of freedom that are specified as input by the user. The tool should be capable of modeling an urban landscape in three dimensions – say, by uploading urban shape files (e.g., of building contours) – and adequately modeling various materials of composition (e.g., concrete, stone, steel, brick, other), in order to develop a representative model for each building. As output, the tool should calculate the energy-integrated intensity as a function of time, and the time-integrated energy spectra, of both gamma and neutron signals, at any user-specified location within the urban landscape. The tool should allow the user to display graphically the results of a specified calculation in a top-down aerial view of the cityscape, as well as views from other angles/perspectives (e.g., street-level horizontal plans). Lastly, the tool should support a way to validate its output by comparing the results to benchmarked code calculations; for this purpose, the tool would calculate attenuation, scattering, shielding, and shadowing effects using simple, well defined geometries.

Grant applications should (1) describe the proposed calculation approach and any modeling assumptions made; (2) specify (with quantitative estimates) the accuracies of the calculation and the anticipated resolution – in energy, time, and position – for both the gamma and neutron output signals, using test landscape configurations with simple geometric shapes; and (3) define how to use the tool (e.g,. how to build a building-by-building and block-by-block model of the urban landscape) and how to exhibit test results, by running calculations on simple geometric configurations.

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

REFERENCES:

1. Oak Ridge National Laboratory, A suite of potentially useful codes is described. (URL: http://www.ornl.gov/sci/radiation_transport_criticality/codes.shtml)

55. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Nuclear power provides over 20 percent of the U.S. electricity supply without harmful greenhouse gases or air pollutants, including those that may cause adverse global climate changes. New methods and technologies are needed to address key issues that affect the future deployment of nuclear energy and to preserve the U.S. leadership in nuclear technology and engineering, while reducing the risk of nuclear proliferation. This topic addresses several of these key technology areas: improvements in nuclear reactor technology for existing light water reactors and evolutionary LWR and gas-cooled reactor designs, advanced instrumentation and control (I&C) for very high temperature gas-cooled reactor applications, advanced I&C for use in high neutron irradiation environments for the Next Generation Nuclear Plant (NGNP) gas-cooled reactor designs, and advanced technologies for the fabrication, characterization and non-destructive testing of high quality nuclear reactor fuel for LWR and Generation IV reactor designs which include advanced fuel cycle management related technologies. 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 21.

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 1-4]. 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 [5, 6]; (2) to improve monitoring of plant equipment performance and aging, using improved diagnostic techniques for in-service and non-destructive examinations [7]; (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 **[6, 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/contamination monitoring devices; computer software enhancements; and U. S. Nuclear Regulatory Commission probabilistic risk assessments or reactor safety experiments, testing, licensing, and site permit issues.

Questions – contact Richard Stark (richard.stark@nuclear.energy.gov)

b. Advanced Technologies for the Fabrication, Characterization of Nuclear Reactor Fuel for Generation IV Reactor Designs, and Fuel for Advanced Fuel Cycle Research and Development—Improvements and advances are needed for the fabrication, characterization and non-destructive examination of nuclear reactor fuel with technologies that could: (1) develop advanced automated, continuous vs. batch mode process fabrication, characterization, and non-destructive testing TRISO fuel for Advanced Gas-Cooled Reactors/NGNP applications **[10, 11,12]**; and (2) provide new small instrumentation for use by the R&D program associated with recycling of spent nuclear fuel to produce fuel and rods for burning plutonium and minor actinides for Fuel Cycle Research and Development Program applications **[8]**. 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 be proposed 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 **[10, 11,12]** to demonstrate the techniques and equipment developed. Actual nuclear fuel specimens may be considered for ATR or ORNL High Flux Irradiation Reactor (HFIR) will need to prove technical feasibility prior to their insertion into the ATR or HFIR for irradiation testing.

Grant applications that address the following areas are NOT of interest and will be declined: Spent fuel separations technologies used in the Fuel Cycle Research and Development Program **[8]** and applications that seek to develop new glove boxes or sealed enclosure designs.

Questions - contact Frank Goldner (frank.goldner@nuclear.energy.gov) for Advanced Fuel Cycle Research and Development related, or Madeline Feltus (Madeline.feltus@nuclear.energy.gov) for Advanced Gas-Cooled Reactors/NGNP applications.

c. Materials Accounting and Control for Domestic Fuel Cycles—Improvements and advances are needed for the development, design and testing of new sensor materials and measurement techniques for nuclear materials control and accountability (including process monitoring) that increase sensitivity, resolution, radiation hardness, while decreasing the cost to manufacture. Grant applications are sought for: (1) Sensors based on radiation detection; (2) New technologies to replace He-3 for neutron detection in accountability instruments; (3) New active interrogation methods, including basic nuclear data (neutron and photo fission, nuclear resonance fluorescence); (4) Non-radiation based (stimulated Raman, laser-induced breakdown spectroscopy, fluorescence, etc.). Grant applications are also sought for the development of new methods for data validation and security, data integration, and real time analysis with defense-in-depth and knowledge development of facility state during design.

Grant applications that address sensitive technologies are not sought.

Questions - contact Bradley Williams (bradley.williams.@nuclear.energy.gov)

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56. 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 area.

a. Identifying, Searching, Accessing, and Communicating Science (Especially as Presented in Scientific and Technical Databases, Data Sets, and Multimedia)—Despite major advances in technological approaches to search and retrieve textual R&D information through federated deep-web resources, a number of significant gaps prevent the search and access of the full range of information and data types. Specifically, gaps exist in (1) the use of real-time multilingual translations to enable access to research in other languages; (2) scaling federated search applications in ways that properly balance search engine speed and comprehensiveness; (3) eliminating duplications across search results; (4) integrating Web 2.0 capabilities, including social networking (e.g. commenting, tagging, rating, or collaborative filtering) that promotes interactive collaborations across scientific communities; and (5) integrating multimedia and numeric data access into traditional textual search and retrieval. Grant applications are sought to address these gaps with innovative technologies that are capable of being adopted across a heterogeneous mix of next generation or existing applications. The intended audiences for proposed technologies include science and engineering researchers, science-attentive citizens, and/or students at various levels.

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57. ADVANCED DIAGNOSTIC TECHNIQUES FOR ELECTRICITY SYSTEMS

Although the United States power grid has maintained a high level of reliability for decades, it 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. While the Nation's lights may remain on, the risks and complexity of achieving sufficient power are growing every day. Remote monitoring technologies can optimize the utilization of transmission and distribution (T&D) assets and improve their operational efficiencies through a smart-grid-enabled infrastructure. For example, optimized capacity can be attainable with dynamic ratings, which allow assets to be used at greater loads by continuously sensing and rating their capacities. Maintenance efficiency involves attaining a reliable state of equipment or “optimized condition.” This state is attainable with condition-based maintenance, which signals the need for equipment maintenance at precisely the right time. Then, system-control devices can be adjusted to reduce losses and eliminate congestion. Among the needs to maintain the electricity delivery systems are smart tools to ascertain the status of both overhead and underground power lines. **Grant applications are sought only in the following subtopics**:

a. Novel Techniques for Power Line Sag and Temperature Monitoring—The power carrying capacity of overhead transmission lines is limited by the loss level at which local heating leads to an excessive temperature rise, causing the conductor to sag [1-2]. This limit is highly dependent on local weather conditions and may be defined by a single span in the line. Conventional dynamic rating schemes are based on seasonal temperature data and tend to be very conservative, in order to avoid outages. Next generation sensors for real-time, accurate dynamic rating will be essential to improving the efficiency of the transmission grid, which in many cases is underutilized by as much as 20%. Therefore, grant applications are sought to develop sensors for measuring power line sag and temperature. Proposed solutions should meet the following requirements:

1) Low cost to allow for large-scale deployment.
2) Self-powered from the line.
3) Ability to measure actual conductor temperature, preferably over the conductor’s length.

4) Ability to measure sag directly.
5) Ability to be easily retrofitted to existing lines.

Proposed approaches should seek to avoid the problems associated with existing techniques for sag and temperature monitoring, which are generally expensive and have not seen widespread deployment on the transmission grid. Conventional methods for sag measurement include tension sensors [1], video camera methods [3], and differential GPS techniques. The use of parallel-strung sensing wires also has been investigated. Many of these methods rely on inference of the sag or temperature from measurements of related parameters and have limited accuracy. Line temperature measurements can be made by surface thermocouples, distributed optical fiber methods [4-6], and infra-red imaging.

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

b. Development of Advanced Diagnostic Techniques for Underground Cables—Siting and permitting is becoming more difficult to obtain for new distribution lines, which are needed to meet the increasing demand from new housing/subdivision/community developments. Although underground cable installations have eased significant environmental and aesthetic concerns, the costs for installing underground cables and their associated O&M costs have nonetheless been a major barrier. For example, the length of time required to restore power outage/disturbance events from underground cables is typically longer than what is typical for overhead cables, as evident from the outage event in 2008 in New York City. Therefore, grant applications are sought to develop advanced diagnostic techniques for real-time prognosis and diagnosis of underground cable conditions, in order to support predictive and condition-based monitoring, maintenance, and operations. Relevant information on cable diagnostic techniques is available through a DOE funded project activity.

Questions – contact Eric Lightner (eric.lightner@hq.doe.gov)

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58. 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, and a substantial penetration of such intermittent sources 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. Compressed Air Energy Storage (CAES) is one of the few technologies able to store hundreds of megawatt hours. However, increases in efficiency, improvements in cost, and reduction in carbon footprint are still required. **Grant applications are sought only in the following subtopic**:

a. Innovative Compressed Air Energy Storage—Compressed Air Energy Storage works by using off peak electricity, preferably from renewable resources, to compress air and then using the compressed air during peak periods as input in a gas turbine. Air can be stored in caverns, salt domes or aquifers. CAES is considered a mature technology, suitable for storing bulk power, but only two facilities have ever been built worldwide. While CAES plants can effectively store energy and generate electricity on demand, they use natural gas as a makeup fuel and, therefore, still have an appreciable carbon footprint.

Recently a number of new options have been suggested for innovative CAES-type storage technologies. Among these are various adiabatic or isothermal CAES versions that make use of liquid CO_2 or nitrogen as a working fluid, mechanical schemes using hydraulics, and novel ideas for storage reservoirs. Such technologies may result in more options for siting facilities, offering a reduced carbon footprint, or providing the possibility of cost-effective medium size installations. Grant applications are sought to investigate a promising innovative CAES-type technology – from the point of view of technical feasibility, efficiency, economics, and carbon footprint – and to develop a detailed conceptual design for a full scale or scalable prototype.

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

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59. 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 Alan Stone (Alan.Stone@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 Alan Stone (Alan.Stone@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 Alan Stone (Alan.Stone@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 inter-connection 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 Alan Stone (Alan.Stone@science.doe.gov)

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60. 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 Alan Stone (Alan.Stone@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 Alan Stone (Alan.Stone@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 Alan Stone (Alan.Stone@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 Alan Stone (Alan.Stone@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 Alan Stone (Alan.Stone@science.doe.gov)

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

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. 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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62. 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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63. 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^o or better, and amplitude control at the level of 0.1% or better. Advanced LLRF systems that can perform vector sum control on ILC cryomodules, thus allowing each cavity to be run at its full potential, are also of interest.

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

65. 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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66. 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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67. 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: (1) high precision retroreflectors for CO_2 lasers (10.6 micron) that are compatible with service behind the ITER first wall for the ITER tangential interferometer/polarimeter system and the ITER divertor interferometer system; (2) a fiber-optic-based laser endoscope for remote monitoring of optical quality and ablation of coated deposits on diagnostic mirrors; (3) a robust shutter that is compatible with operation near the ITER first wall and applicable to U.S. ITER diagnostics; (4) motion-compensating miter bends in an overmoded, corrugated microwave waveguide; (5) broadband polarization separators in an overmoded corrugated waveguide for the ITER low-field-side reflectometer system; (6) a 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; and (7) robust, reliable mixers and local oscillators (LOs) in the 200-300 GHz range for 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; 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, in order 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 that are applicable to plasma simulations, incorporate an expanded number of plasma features, and integrate multiple physics processes. Areas of interest include, but are not limited to, (1) algorithms incorporating advanced mathematical techniques such as neural networks, sparse linear solvers, and adaptive meshes; (2) multiscale algorithms; (3) verification and validation tools, including efficient methods for facilitating comparison of simulation results with experimental data and synthetic diagnostics; (4) data management, visualization, and analysis tools for local and remote multi-dimensional time-dependent datasets resulting from large scale simulations or experiments; (5) techniques for coupling simulation codes, including coupling across different computer platforms and through high speed networks; (6) methodologies for building highly configurable and modular scientific codes and flexible data interfaces; and (7) 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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68. 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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