PROGRAM AREA OVERVIEW
OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

The Department of Energy is committed to reducing America's dependence on foreign oil and developing energy efficient technologies for buildings, homes, transportation, power systems and industry. The mission of the Office of Energy Efficiency and Renewable Energy (EERE) is to strengthen America's energy security, environmental quality, and economic vitality in public-private partnerships that: enhance energy efficiency and productivity; bring clean, reliable and affordable energy technologies to the marketplace; and make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life.

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

It is estimated that the energy technologies and practices supported by the EERE programs have saved Americans many billions of dollars in energy costs over the past decade. These savings are projected to dramatically increase as emerging and new energy technologies are developed and commercialized. These energy savings are accompanied by parallel reductions in emissions of pollutants that affect human health and in the production of greenhouse gases. The EERE programs in renewable energy have advanced the state of technologies in such areas as solar, wind, and biomass to the point where renewables have been projected to supply as much as 28 percent of the Nation's energy by 2030.

Program activities are conducted in partnership with the private sector, state and local government, DOE national laboratories, and universities. EERE also works with stakeholders to develop programs and policies to facilitate the deployment of advanced clean energy technologies and practices.

For additional information regarding the Office of Energy Efficiency and Renewable Energy priorities, click here.

1. USE OF CELLULOSIC BIOMASS TO PRODUCE BIOFUELS

The President, in his State of the Union address (January 31, 2006), outlined his Advanced Biofuels Initiative which seeks to break our national dependence on imported oil by accelerating the development of domestic, renewable alternatives to petroleum-based transportation fuels. The President announced his Biofuels Initiative, an effort to develop cost competitive cellulosic biofuels as transportation fuels by 2012. In order to reach the President's goal, the Office of the Biomass Program has set an internal R&D goal of reaching an ethanol cost of $1.07 (based on 2002 dollars) per gallon from cellulosic feedstocks (agricultural residues such as stalks and straws, forest-based resources, and dedicated energy crops such as switch grass and hybrid poplars) by 2012.

One important component of successfully achieving the goal is ensuring that cost competitive feedstocks for biofuels production are widely and sustainably available in sufficient quantity and at reasonable cost. Feedstock cost represents the largest single cost element in producing a gallon of ethanol. The Departments of Energy and Agriculture jointly released a "Billion Ton Study" in April 2005 that determined that the United States has the potential to sustainably generate about 1.3 billion dry tons of biomass feedstock annually. These potential resources are available primarily as agriculture and forest derived feedstocks, and are enough to produce biofuels needed to displace 30 percent of our current gasoline consumption. Research is needed on major biomass resources which could be supplied to biorefineries for conversion to biofuels and bioproducts. Biorefineries are processing facilities that extract carbohydrates, oils, lignin, and other materials from biomass, convert them into multiple products such as transportation fuels, power, and products. The biomass resources should be sustainably available in large quantities, at low cost, and of appropriate quality.

The other components of successfully achieving the goals are cost competitive conversion of biomass to fuels and other products by both biochemical and thermochemical conversion pathways.

The Office of Biomass Program investigates biochemical conversion pathways for the utilization of the cellulose and hemicellulose fractions of biomass to produce ethanol via pretreatment to breakdown the hemicellulose to fermentable 5 and 6-carbon sugars, enzymatic hydrolysis to break the cellulose portion of biomass down to glucose, and fermentation routes for C5 and C6 sugars to make ethanol. Current cost of cellulosic ethanol production is too high to compete in the market. New and improved technologies and resulting cost reductions are needed to make cellulosic biomass-based technologies more competitive.

The other area of interest of the Office of Biomass Program is thermochemical conversion pathways in which biochemical biorefinery residues, forest residues, agricultural residues, and future energy crops would be considered for conversion (e.g. by gasification, pyrolysis) into an intermediate, and synthesized into fuels and/or chemicals.

Grant applications are sought <u>only</u> in the following subtopics:

a. Handling and Preprocessing of Ensiled (Wet) Biomass—The emerging biorefining industry is dependent on having a large and sustainable supply of biomass resources provided at an effective cost and quality. The joint U.S. Department of Energy and U.S. Department of Agriculture billion ton study identified a biomass resource potential of about 998 million tons (including agriculture residues and new perennial crops) that could come from agricultural lands[1]. While much of this agricultural biomass resource can be handled and managed with low moisture (less than 15%) forage system technologies, the greater portion of this tonnage will be produced in regions of the U.S. where climate and cropping practices will require these same agriculture biomass resources to be handled in high moisture systems (greater than 50% moisture). These high moisture biomass feedstock systems will require the biomass to be stored under wet, anaerobic conditions (ensiled)[2].

Once the producer has harvested and stabilized the biomass in an ensiled storage system, the challenge is an effective high volume delivery system to take ensiled biomass from multiple on-farm storages to the biorefinery. The dry matter density of the biomass for cost-effective transportation, aerobic stability of the biomass throughout the entire handling and transport system to prevent carbohydrate loss, and

delivered feedstock quality for efficient conversion to biofuels and products are key points that need to be addressed in these post-storage handling, preprocessing and transport systems[3]. Additionally, grant applications should demonstrate cost improvements that can be quantifiably evaluated in the context of a feedstock supply system cost target of $35/dry ton (based on 2002 dollars). Cost improvements could include, but are not limited to, efficiency improvements, credit for improved feedstock value, co-products, etc. Grant applications are sought to develop: 1) systems for biomass removal from multiple on-farm storage units, 2) biomass preprocessing to achieve biorefinery feedstock quality/format specifications and optimize dry matter density for transportation to a biorefinery, and 3) engineered systems for optimized transportation and handling of high moisture biomass. It is expected that projects awarded from this subtopic will lead to lower costs for high moisture biomass systems and higher quality biomass delivered to biorefineries, and that those systems will optimally interface with current agricultural and transportation infrastructures.

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

Subtopic a References:

1. "Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply," U.S. DOE/ U.S. Department of Agriculture, April 2005. (Full text available at: http://bioenergy.ornl.gov. Click on title under "News and Events" in center of page.)

2. Berger, L. L. and Bolsen, K. K., "Silage for Dairy Farms: Growing, Harvesting, Storing and Feeding," Proceedings of the Natural Resource, Agriculture, and Engineering Service (NRAES) Conference, Camp Hill, PA, January 23-25, 2006; NRAES, 2006. (ISBN-10: 1-933395-06-0) (News release and ordering information available at: http://www.nraes.org/publications/nraes181.html)

3. "Roadmap for Agricultural Biomass Feedstock Supply in the United States," U.S. DOE Office of Energy Efficiency and Renewable Energy, November 2003. (Full text available at: http://www.inl.gov/bioenergy/docs/biomass_roadmap2003.pdf)

b. Densification/Granulation of Dry Biomass—Biomass from agricultural crops will be available to a biorefinery in a dry (moisture content less than 15%) or wet form. Biomass material can be densified into square or round bales for storage and transportation. The attainable bulk density for most grasses, straw, and stover using the existing baling equipment is about 10 pounds per cubic foot. This bulk density does not max out the allowable pay load of the transport equipment. Baled biomass is difficult to handle and store safely.

Most animal feeds are pelletized to increase their bulk density to roughly 30-40 pounds per cubic foot. Dense pellets can be handled and stored as bulk granules using conventional equipment and existing infrastructure for grain handling. Pelletized materials are less prone to spoilage and combustion than loose or baled biomass. Grinding and mixing operations reduce variability in physical and chemical characteristics. The composition of pelletized material can be rationed to specific ingredients (fiber content, lignin, etc) to maximize conversion efficiencies. This enhances the quality and increases the value of biomass to biorefinery.
The existing pelletization requires drying, grinding and conditioning process in order to produce durable pellets. Mechanically formed pellets are easy to handle and can be transported efficiently.

Unfortunately the numerous processes involved in producing pellets are energy and power intensive and require expensive capital equipment. Many biomass materials especially those from grasses, straw and stover do not form durable pellets without an additional binder that would add to the cost of pellets.

Grant applications are sought to overcome one or several of the technical barriers against producing economical biomass pellets. New technologies are sought to reduce the moisture content of biomass in the field - for example, using solar energy or natural drying processes. The biomass can also be modified through physical and chemical modifications to make it easier to be pelletized. There are also opportunities to reduce power requirement of pelletizing equipment through designing new pelletization equipment.

Grant applications are also sought to address any of the processes that would lead to producing biomass pellets economically. The biomass of interest to be pelletized at this time is corn stover, cereal straws, and switchgrass. Other crop residues or grasses may be considered if they are of regional economic significance. The application should clearly show and quantify how a proposed research and technology development will lead to cost reductions in pelletization of biomass. The proposal should also address any improvements in the quality of biomass as a result of pelletization processes. Additionally, proposed technologies should demonstrate cost improvements that can be quantifiably evaluated in the context of a feedstock supply system cost target of $35/dry ton (based on 2002 dollars).

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

Subtopic b References:

1. Tabil, L. and Sokhansanj S., "Process Conditions Affecting the Physical Quality of Alfalfa Pellets," *Applied Engineering in Agriculture*, 12(3): 345-350, 1996. (ISSN: 0883-8542) (Ordering information available at: http://www.asabe.org/pubs/PubCat02/periodicals.html)

2. Mani, S., et al., "Economics of Producing Fuel Pellets from Biomass," *Applied Engineering in Agriculture*, 22(3): 421-426, 2006. (ISSN: 0883-8542) (Abstract and ordering information available at: http://asae.frymulti.com/abstract.asp?aid=20447&t=1)

c. Fermentation/Biochemical Conversion—Grant applications are sought for innovative technologies for fermentation of the sugar portions of lignocellulosic biomass to fuels and chemicals.

Robust strains that ferment sugars at high rates with minimum byproduct formation must be developed for commercial scale[1]. The ability to develop robust, industrially useful fermentation strains to meet performance and cost metrics listed below will require the acquisition of substantial knowledge regarding the fundamental factors that limit efficient sugar bioconversion in hydrolysate. A collective knowledge on strain improvement including deeper understanding of strain physiology, metabolic engineering options, hydrolysate toxicity as well as process considerations are required.

In the case of lignocellulosic biomass to ethanol, applicants must address the following metrics. The organism must be able to be produced at low cost via on-site production with hydrolysate sugars and minimal nutrients or supplied at low cost (pennies per gallon ethanol) as in the corn ethanol industry.

Inhibitors in hydrolysate such as acetic acid can severely inhibit the cell growth, so overcoming such growth inhibition is critical.

Working in a solids environment presents special challenges for an organism. To meet the $1.07 target, the organism must be able to ferment hydrolysate with a minimum total solids content of 20% (with 11-15% total sugars), with minimal nutrient supplement and hydrolysate conditioning. A tolerance to at least 5% ethanol, preferably to 8-10% (w/w) is needed to achieve higher ethanol titer[2].

Improving the xylose to ethanol process yield (currently 25-50%) to 85% is essential to meet the $1.07 target. The xylose fermentation rate needs to be enhanced 3 to 10 fold to approach the glucose fermentation rate. Reducing the toxic effect of inhibitors on pentose fermentation by either improving microbial resistance to the hydrolysate or minimizing toxic levels during pretreatment and subsequent process treatment must also be achieved. Improved microbial resistance can be achieved by traditional adaptation or a more rational approach using advanced biological tools available now. It would be beneficial to understand the toxic mechanisms not only to help develop superior strains but also to provide guidance in pretreatment process.

The investigator must use slurries that are consistent with what is being produced at the lab and pilot scales at the National Renewable Energy Laboratory (NREL).

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Subtopic c Reference:

1. Aden et al., "Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover," Design Report, U.S. DOE National Renewable Energy Laboratory, June 2002. (Full text available at: http://www.nrel.gov/docs/fy02osti/32438.pdf)

2. "Biochemical Process Technology Target for 2012," Section 4.2.1 of 30x30: A Scenario for Supplying 30% of 2004 Motor Gasoline with Ethanol by 2030, U.S. DOE Office of Energy Efficiency and Renewable Energy, 2006. (Full text available at: http://30x30workshop.biomass.govtools.us/. On menu under photos, click on "Supporting Documents". Scroll down to green heading "Agricultural Residues", and click on "30x30 Lab Scenario (Section 4)". Scroll down to title, above, at Section 4.2.1.

d. Distributed Biomass Pyrolysis and Bio-oil Upgrading/Thermochemical Conversion—
Grant applications are sought to improve the quality and energy density of biomass-based pyrolysis oil (bio-oil). The R&D needs are a fast pyrolysis process, to produce a liquid fuel oil with a high energy density per unit volume; and a ganged upgrading process that allows the final product oil to be used directly as a fuel or chemical or as refinery feedstocks for renewable fuels and specialty chemicals.

Biomass pyrolysis is the thermal depolymerization of biomass at modest temperatures in the absence of additional oxygen. The slate of products from biomass pyrolysis depends on the process temperature, pressure, and residence time. Charcoal yields of up to 35 % can be achieved for slow pyrolysis at low temperature, high pressure, and long residence time. Fast pyrolysis is used to optimize the liquid

products in an oil known as pyrolysis oil, bio-crude or bio-oil. High heating rates and short residence times enable rapid biomass pyrolysis with minimal vapor cracking; this maximizes liquid product yields with up to 80% efficiency. Pyrolysis oils are multi-component mixtures rich in oxygenated materials that, in general, retain the overall elemental composition of the biomass feed. Oil from flash pyrolysis is usually a dark brown, free-flowing liquid with a distinctive smoky odor. Oil from slow pyrolysis is more like a tar. In addition, pyrolysis oils can be separated because of differences in the chemical nature of the constituents. For example, excess water can preferentially separate components that are soluble in water (the "aqueous fraction") and those that are not (the "pyrolytic lignin").

Pyrolysis oils have been used for heat and power generation, usually requiring only minor modifications to existing equipment. Pyrolysis oil has been successfully used as boiler fuel and has also showed promise in stationary diesel engine and gas turbine applications. Upgrading pyrolysis oil to a liquid transportation fuel poses technical challenges, but recently separation and upgrading of the pyrolytic lignin using traditional petroleum refinery unit operations has shown technical and economic promise for producing precursors to renewable fuels and specialty chemicals.

Pyrolysis oil production in a petroleum refinery may be problematic because of economic issues of transport and storage of biomass on site. Transportation costs have historically been a major barrier for biomass upgrading, becoming "very significant after 20 miles, and usually prohibitive beyond 100 or 200 miles." A more promising option may be the distributed production of pyrolysis oil at distributed locations, followed by transportation of pyrolysis oil to a central processing facility.

Grant applications are sought to determine the technical and economic feasibility of distributed production of pyrolysis oil. Two classes of systems need to be considered, modular skid mounted systems (remote, off-grid locations) and permanent facilities. This project should not include construction of facilities, but may include production of pyrolysis oil to obtain material and energy balance information, and oil properties. A successful Phase 1 project may lead to a Phase 2 prototype demonstration project.

The application should address:
1) Identification and characterization of feedstocks
2) Characterization of pyrolysis oil
3) Preliminary process flow diagram, material and energy balances, and equipment lay-out
4) Proposed feed preparation, drying and utilities systems. For off-grid applications a discussion of electricity generation facilities will be required.
5) Preliminary equipment lists and costs and
6) Preliminary environmental evaluation (air, water, solids)

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Subtopic d References:

1. Czernik, S. and Bridgwater, A. V., "Overview of Applications of Biomass Fast Pyrolysis Oil," *Energy & Fuels*, 18(2): 590-598, February 2004. (Abstracts and purchasing information available at: http://pubs.acs.org/cgi-bin/abstract.cgi/enfuem/2004/18/i02/abs/ef034067u.html. To purchase article, see menu at top of page.)

2. Oasmaa, A. and Czernik, S., "Fuel Oil Quality of Biomass Pyrolysis Oils - State of the Art for the End User," *Energy & Fuels*, 13(4): 914-921, April 1999. (Abstracts and purchasing information available at: http://pubs.acs.org/cgi-bin/abstract.cgi/enfuem/1999/13/i04/abs/ef980272b.html. To purchase article, see menu at top of page.)

3. Solantausta, Y., et al., "Assessment of Liquefaction and Pyrolysis Systems," *Biomass & Bioenergy*, 2(1-6): 279-297, 1992. (ISSN: 0961-9534) (Abstract and ordering information available at: http://www.sciencedirect.com/. Search by document title.)

4. Solantausta, Y., et al., "Feasibility of Power Production with Pyrolysis and Gasification Systems," *Biomass & Bioenergy*, 9(1-5): 257-269, 1995. (ISSN: 0961-9534) (Abstract and ordering information available at: http://www.sciencedirect.com/. Search by document title.)

2. SOLAR ENERGY

The U.S. Department of Energy is beginning a new Solar America Initiative (SAI) to accelerate the development of advanced photovoltaic systems with the goal of making photovoltaics (PV) cost-competitive with other forms of renewable electricity by 2015. In that context, we need grant applications that complement and enhance the Solar America Initiative. In simple terms we want to invite small businesses to contribute to SAI by "filling technology holes" in the vast array of SAI manufacturing, systems and projects. We intend to bolster the likelihood of success for SAI through innovative complementary technologies that support the cost reductions needed in photovoltaic manufacturing and system energy production.

a. Monitoring and Self-Diagnosing PV Systems, Components and Modules—As PV becomes more widely used during the Solar America Initiative, the value of PV systems will be more intensely scrutinized and the actual performance of systems versus predictions and actual weather values will become progressively more important. In addition, as PV technologies change and new ones are introduced, module and system reliability may be critical to success. Reliability is particularly important for new module and inverter technologies. Grant applications are sought for innovative methods to monitor PV system and component performance and to relate performance to actual weather (e.g. solar insolation, temperature, humidity and temperature) so as to ascertain failure and loss mechanisms as quickly as possible. Proposed monitoring and diagnostics can be embedded in system components resulting in, for example, state-of-the-health system sensors, smart metering, load management controllers and smart inverters.

Questions - contact Alec Bulawka (alec.bulawka@hq.doe.gov)

Subtopic a Reference:

1. "Solar America Initiative," U.S. DOE Office of Energy Efficiency and Renewable Energy Website. (URL: http://www1.eere.energy.gov/solar/solar_america/about.html)

b. PV (Crystalline Silicon and Thin Film) Manufacturing Diagnostics—Grant applications are sought for diagnostic technologies to improve yield and reduce cost of crystalline silicon PV manufacturing of cells and modules. Industry has identified many specific issues and high priority areas include, but are not limited to: 1) identification and resolution of wafer stress and wafer cracks; 2) handling technologies for improved robot transfer forces, rates and belt transfers; 3) improved interconnect technologies for auto wafer assembly, back contact interconnects, and wafer assembly stress management; 4) new air conveyors and improved manufacturing data tracking.

Applications are also sought for diagnostic and control technologies to improve yield, increase materials utilization and reduce cost of thin film PV module manufacturing. Areas of interest include but are not limited to such high priority issues as: process characterization through improved sensors and control technologies for maintaining coating flux density, distribution of the flux emerging from the coating source, mean energy of the flux in order to assure reproducible stoichiometry, high deposition rates, better materials utilization, microstructure control (i.e. grain size, morphology, texture and porosity), coating uniformity, film stress, and film adhesion.

Questions - contact Alec Bulawka (alec.bulawka@hq.doe.gov)

Subtopic b References:

1. "PV (Photovoltaic) Manufacturing R&D," U.S. DOE National Renewable Energy Laboratory Website. (URL: http://www.nrel.gov/ncpv/pv_manufacturing/)

2. Board on Manufacturing and Engineering Design, "Unit Manufacturing Processes: Issues and Opportunities in Research," National Academies Press, 1995. (Online text and ordering information available at: http://darwin.nap.edu/books/0309051924/html/1.html)

c. Non-Inverter Balance-of-System Components and Net-Metering Technologies—Inverters and related balance-of-system (BOS) components are critical elements in the performance of photovoltaic power systems developed through SAI. Inverters will likely be the center of BOS attention for almost all the SAI projects. There are many opportunities to improve non-inverter BOS components for PV applications for grid interactive applications. Grant applications are sought for: 1) smart main and branch circuit breakers that provide the means to monitor whole-building or branch power usage; 2) simplified or standardized wiring methodologies for building integrated PV applications; 3) innovative surge protection for complete system or building protection from surges on either the DC or AC side, junction boxes that provide simplified intra- and inter-array wiring; 4) innovative mounting methodologies and installation concepts; 5) state-of-system health monitoring capabilities, system predictive monitoring, and safety and logic controls for complete system code and standards compliance.

The ability to use PV generated electricity to offset the total load of the customer during peak usage or critical power-needed times has developed into one of the more important incentives in the economics of a PV system. In order to make PV more cost-effective with value added, it is logical to look for simple net metering methodologies, communications and control functions, where customers receive the full value of their PV output without excessive net-metering fees or requirements. Integrating PV systems into electric utility distribution systems for net metering should be a win-win prospect for the consumer

and the utility. Grant applications are sought for the development of complete system controllers or methodologies that provide value to both the consumer and the utility. The controllers may be integrated into the complete systems or serve as ancillary devices connected to smart hardware such as inverters or smart circuit breakers. Applications are also sought for predictive methodologies for value-added, self diagnostics for PV systems, smart and adaptive hardware including system controls that interface with a wide variety of disconnect devices, circuit breakers, energy storage, or ancillary power producers. Applications may include grid-connected concepts including those that provide a variety of uninterruptible power for critical loads or selective load shedding for aiding highly stressed utilities. Applications are also sought to address the requirements for automated revenue-grade monitoring of PV systems for net metering that avoids the need for additional utility meters. This may be addressed as an ancillary or inverter-integrated energy monitoring methodology and may include secure communications that allows the utility to override the required anti-islanding functions.

Questions - contact Alec Bulawka (alec.bulawka@hq.doe.gov)

Subtopic c References:

1. Ton, D. and Bower, W., "Summary Report on the High-Tech Inverter Workshop," U.S. DOE, Office of Energy Efficiency and Renewable Energy, January 2005. (Full text available at: http://www1.eere.energy.gov/solar/pdfs/inverter_II_workshop.pdf)

2. Townsend, T. C., et al., "A New Performance Index for PV System Analysis," Conference Record of the First World Conference on Photovoltaic Energy Conversion, Waikoloa, HI, December 1994, 1: 1036-1039, IEEE, December 1994. (Abstract and ordering information available at: http://ieeexplore.ieee.org/servlet/opac?punumber=3971

d. Non-Cell Concentrator Photovoltaic System Components—The development of concentrator PV systems is generating recent interest because of new high efficiency III-V solar cells approaching 40% solar conversion efficiency. Grant applications are sought for the development of non-solar cell components of CPV systems. Such innovation includes optical concentration designs such as refractive, reflective and holographic concepts. Another component relates to tracking structures, control logic for tracking, torque leveraging technologies involving gears or hydraulics, and wind loading protection schemes. Mechanical engineering innovation includes structural designs to reduce steel content (due to rising steel prices) while maintaining structural integrity, avoidance of mechanical resonances, while meeting wind loading requirements. Another mechanical engineering area for innovation includes solar cell cooling such as phase change concepts (heat pipes or thermosiphons), innovative materials with high thermal conductivity and low electrical resistance, as well as active cooling concepts. Applications are also sought for integrated CPV concepts such as integrated building CPV concepts and luminescent concentrator concepts.

Questions - contact Alec Bulawka (alec.bulawka@hq.doe.gov)

Subtopic d References:

1. Proceedings of the International Conference on Solar Concentrators for the Generation of Electricity or Hydrogen, Scottsdale, AZ, May 2005. (CD of Conference papers available free of charge. Contact Sandy Padilla. Email: sandy_padilla@nrel.gov. Phone: 303-384-6495.)

2. Shaheen, S. E., et al., "Organic-Based Photovoltaics: Toward Low-Cost Power Generation," *Materials Research Society Bulletin*, 30: 10-15, 2005. (ISSN: 0883-7694)

3. Brabec, C. J., et al., "Plastic Solar Cells," *Advanced Functional Materials* 11(1): 15-26, 2001. (ISSN: 1616-301X Print) (Abstract available at: http://www3.interscience.wiley.com/. Toward bottom of screen, BROWSE by product type: Journals, then BROWSE by [journal] title. In column at right, search by citation, above)

4. Coakley, K. M. and McGehee, M. D., "Conjugated Polymer Photovoltaic Cells," *Chemistry of Materials*, 16: 4533-4542, 2004. (ISSN: 0897-4756) (Abstract available at: http://pubs.acs.org/journals/cmatex/index.html. At top of page, click on "Search the Journals." Under "Citation Finder" search using bibliographic information, above.)

5. Golberg, D., et al., "Metal-Filled Nanotubes: Synthesis, Analysis, Properties and Applications," AIP Conference Proceedings, 723[Electronic Properties of Synthetic Nanostructures]: 229-233, 2004. (ISBN: 0-7354-0204-3) (Abstracts and ordering information available at: http://proceedings.aip.org/proceedings/. Search for Proceedings Volumes.

6. Kazuhito H., et al., "TiO_2 Photocatalysis: A Historical Overview and Future Prospects," *Japanese Journal of Applied Physics*, 44(12): 8269-8285, December 2005. (ISSN: 0021-4922 Print) (Abstract available at: http://jjap.ipap.jp/link?JJAP/44/8269)

7. Fujishima, A., et al., "TiO_2 Photocatalysis - Fundamentals and Applications," Tokyo: BKC, Inc., 1999. (ISBN: 4-939051-03-X) (Photographs, from book, of TiO_2 photocatalyst applications available at: http://netserv.ipc.uni-linz.ac.at/~dieter/DsWeb/Research/Detox/Photocat.pdf)

8. Koida, M. L., et al., "Effect of A-site Cation Ordering on the Magnetoelectric Properties in $[(LaMnO_3)_m/(SrMnO_3)_m]_n$ Artificial Superlattices," *Physical Review B*, 66(14): 144418-144424, October 2002. (ISSN: 0163-1829)

9. Carrette, L., et al., "Fuel Cells: Principles, Types, Fuels, and Applications," *ChemPhysChem*, 1(4): 162 – 193, December 15, 2000. (ISSN: 1439-4235) (Abstract and access-purchasing information available at: http://www3.interscience.wiley.com/. Toward bottom of screen, BROWSE by product type: Journals, then BROWSE by [journal] title. In column at right, search by citation, using bibliographic information, above.)

3. HYDROGEN DELIVERY AND PRODUCTION

President Bush announced the Hydrogen Fuel Initiative (HFI) in his Presidential Address in January 2003. The objectives of this Initiative are to reduce our dependence on imported oil, to increase our

energy security, reduce greenhouse gas emissions, and reduce air emissions. The use of hydrogen as an energy carrier and fuel cell vehicles can help meet all of these objectives.

Cost effective and energy efficient transport and delivery of hydrogen from central or distributed hydrogen production facilities will be an important part of the hydrogen infrastructure that will enable widespread use of hydrogen for transportation and other energy needs. Significant research and development is needed on suitable delivery technologies to achieve the delivery cost, energy efficiency, and performance targets as described in the Hydrogen, Fuel Cells, and Infrastructure Multi-Year Research, Development, and Demonstration Plan[1].

Specifically, grant applications are sought to address three key delivery technologies; off-board bulk hydrogen storage, hydrogen liquefaction, and hydrogen compression.

In addition, research and development of low-cost, highly efficient hydrogen production technologies from diverse sources is also needed. Photoelectrochemical hydrogen production, in an early stage of development, depends on a breakthrough in materials development. The primary research in this area is progressing on three fronts: 1) the study of high-efficiency materials to attain the basic science understanding needed for improving lower-efficiency low-cost materials; 2) the study of low-cost durable materials to attain the basic science understanding needed for modifying higher-efficiency, lower-durability materials; and 3) the development of multijunction devices incorporating multiple material layers to achieve efficient water splitting. Grant applications are sought in these areas of production of hydrogen using photoelectrochemical technology.

a. Off-Board Hydrogen Bulk Storage—In order to effectively handle hourly, weekday to weekend, and seasonal hydrogen demand variations, the hydrogen production and delivery infrastructure will require cost effective bulk storage of hydrogen. Bulk storage of gaseous hydrogen avoids the cost and energy needed for hydrogen liquefaction. Current gaseous hydrogen storage relies on steel pressure vessels for storage of 2,000-6,000 psi hydrogen. Such pressure vessels have a purchase cost in the neighborhood of $800/kg of hydrogen stored. The HFI Program is targeting a cost of $300/kg of hydrogen. Several approaches have been suggested including lower cost, high pressure fiber wrapped or other composite structures, cold gas storage that increases the hydrogen density through both lower temperature and high pressure, and the use of novel solid carriers within the storage vessel that would allow higher density gas storage for a given pressure. There may be other approaches as well. Grant applications are sought to develop lower cost bulk hydrogen gaseous storage technology that can ultimately approach the long term target of $300/kg of hydrogen stored capital cost.

Questions - contact Grace Ordaz (grace.ordaz@hq.doe.gov)

b. Hydrogen Liquefaction—Cryogenic liquid hydrogen has a much higher volumetric density than gaseous hydrogen resulting in much lower transport and storage costs. However, current hydrogen liquefaction technology is costly and consumes more than 30% of the energy in the hydrogen. Grant applications are sought to dramatically reduce the cost and increase the energy efficiency of hydrogen liquefaction.

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c. Hydrogen Compression—Current hydrogen compression technology is not as reliable as desired which results in high costs. The reciprocating compressor technology typically used for large volume throughput compression utilizes lubricants which can contaminate the hydrogen. Grant applications are sought for improved hydrogen compression technology for refueling sites (50-2,000 kg/day hydrogen throughput with compression from 50-200 psi to 5000-12,000 psi) and for hydrogen pipeline transmission (100,000 -1,000,000 kg/day throughput with compression from 300 psi to 1,000-2,000 psi).

Questions - contact Grace Ordaz (grace.ordaz@hq.doe.gov)

d. Hydrogen Production—Hydrogen can be produced from a variety of domestic resources utilizing several different production technologies. Of particular interest for the long term is direct photoelectrochemical hydrogen production. Grant applications are requested for research and development of photoelectrochemical materials that show capability of achieving a band gap of 2.0 - 2.3 eV band gap while maintaining a chemical conversion process efficiency of 10 -12% with a material that will be durable enough to last 1000 – 5000 hours.

Questions - contact Grace Ordaz (grace.ordaz@hq.doe.gov)

References:

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2. "FreedomCAR and Fuel Partnership Hydrogen Delivery Roadmap," November 2005. (Full text available at: http://www.eere.energy.gov/hydrogenandfuelcells/delivery/pdfs/dtt_roadmap_11-05ver1_final_03-21-06.pdf)

3. "2005 Annual Progress Report: DOE Hydrogen Program," U.S. DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program, November 2005. (Full text available at: www.eere.energy.gov/hydrogenandfuelcells. In center of page under "Site Updates", click on 2nd bullet. **Note:** *2006 Annual Progress Report* will be posted this fall.)

4. "Solar and Wind Technologies for Hydrogen Production: Report to Congress," U.S. Department of Energy, December 2005. (Full text available at: http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/solar_wind_for_hydrogen_dec2005.pdf)

5. Mintz, M, et al., "HDSAM: Hydrogen Delivery Scenario Analysis Model to Analyze Hydrogen Distribution Options," *Transportation Research Record, Journal of the Transportation Research Board*, No. 1983, December 2006. (Abstract and ordering information available at: http://pubsindex.trb.org/document/view/default.asp?lbid=777833)

4. WIND ENERGY RELIABILITY AND COST REDUCTION

Enhanced integration with the electric power grid and improvements in wind turbine reliability and performance would enable wind to become a more widely used source of energy with higher levels of system penetration. This topic solicits innovations in wind resource management, advanced sensors and control systems, and manufacturing and assembly techniques for wind energy systems. Applicants must explain the commercial viability of their proposed technology and clearly demonstrate the ability to proceed to hardware development, fabrication, testing, and manufacture of components and devices. Grant applications outside of the subtopic descriptions will not be considered.

a. Smart Wind Grid Integration Systems—Wind energy is serving a growing need for centralized power facilities. Wind turbines are also being deployed in greater numbers in smaller distributed applications ranging in size from a few kilowatts to 10 megawatts or larger. Integration and control of these systems will be crucial to assuring grid reliability and achieving maximum benefit. Grant applications are sought to develop technologies that improve management of the wind energy generation as well as energy storage technologies to achieve more efficient integration of wind energy into the existing electric power grid. Technologies to be considered include real time and predictive wind monitoring sensors and tools to assist grid operators in controlling system stability, frequency and phase support, fault tolerance, and transmission capacity from wind energy systems. Grant applications are also sought for technologies that improve communications and control of distributed wind systems. Proposed technologies to be considered could include such capabilities as improved, real-time generation and load forecasting as well as hourly ramp-rate forecasting; reliable user-friendly prediction of wind resource availability; control and aggregation of advanced energy storage for wind (such as Vehicle-to-Grid), and improved DC transmission integration with wind.

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

b. Wind Turbine Health Monitoring Systems—As wind energy systems increase penetration into the national electrical power base, wind turbine reliability 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. These tools should consist of advanced sensor systems and instrumentation in addition to real-time performance and component failure models that can be used to determine structural health and predict maintenance needs, reducing unscheduled outages and predicting failures in advance. Proposed systems must be capable of withstanding extreme environments, including high temperatures, high humidity, extreme cold, corrosive offshore environments, and wind-blown sand and dust. 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. Sensors and data acquisition systems must be flexible in nature, capable of providing a variety of cross cutting health monitoring applications, and easily integrated into the total wind control platform. Systems should be capable of integration into wind turbine fleets or remote, stand alone, unattended turbines. The Phase I effort should lead to a demonstration of the new health monitoring system in Phase II, in either simulated or actual extreme environments.

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

c. Wind Turbine Operating and Control Systems (Sensors and Actuators)—As wind systems become more an integral part of the electrical power grid, their real time operation and control become

critical. Current monitoring and operating practices are very limited and simplistic, in spite of the fact that as wind energy systems become larger and more costly, the opportunity to cost-effectively employ sensors, controls, and actuators becomes more feasible. Grant applications are sought for integrated wind turbine operating and control systems that allow improved power conversion and power quality. The proposed system must be designed to withstand and react to extremely violent and rapidly changing operating environments. System actuators must respond rapidly and be directed at primary sources of load control or power regulation. They may consist of other modes of actuation heretofore not considered. Sensors, controls, actuators, and electronics must respond at speeds commensurate with the forces, loads and rates of flow impacting the renewable power system. The Phase I effort should lead to a demonstration in Phase II of a balanced system design that will deliver greater cost-effectiveness, integration into the total control system for the renewable generating source must be seamless, acquiring and processing information in a manner that improves the control response of the system and reduces the cost of energy.

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

d. Advanced Manufacturing and Assembly Techniques for Wind Energy Systems—
Large utility scale wind turbines are getting so large that transportation limitations are driving final, onsite assembly costs. New tools, methods and designs are needed to reduce manufacturing cost, improve speed of fabrication and improve quality for both central manufacturing facilities and onsite manufacturing. Most of today's small, distributed wind turbines are made in limited production runs, with varying component/subsystem suppliers and a high degree of customization. There is a need for techniques that would enable high volume production and new approaches for manufacturing key components; for example, hybrid composite/steel structures have the potential to replace current tower designs which are relatively expensive and sometimes lack aesthetic appeal. Grant applications are sought for innovations in the areas of advanced approaches for assembly, component manufacturing, materials or fiber processing, materials handling, and turbine installation and erection. Proposed techniques must help reduce the cost of assembly and installation while having a limited impact on overall capital cost. Techniques should also consider long-term implications such as maintenance, refurbishment, replacement and recycling.

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

References:

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2. Verbruggen, T. W., "Wind Turbine Operation & Maintenance Based on Condition Monitoring: WT-OMEGA," ECN (Energy research Center of the Netherlands) Final Report, January 2003. (Full text available at: http://www.ecn.nl/docs/library/report/2003/c03047.pdf.)

3. Martí, I., et al., "Evaluation of Advanced Wind Power Forecasting Models," presented at EWEC06: European Wind Energy Conference and Exhibition: Business, Science & Technology, Athens,

Greece, Feb. 27-Mar. 6, 2006, 2006. (Full text available at: http://anemos.cma.fr/download/publications/pub_2006_paper_EWEC06_WP2results.pdf.)

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

5. Kariniotakis, G., et al., "Next Generation Short-Term Forecasting of Wind Power - Overview of the Anemos Project," presented at EWEC06: European Wind Energy Conference and Exhibition: Business, Science & Technology, Athens, Greece, Feb. 27-Mar. 6, 2006. (Full text available at: http://anemos.cma.fr/download/publications/pub_2006_paper_EWEC06_WP9overview.pdf.)

5. TECHNOLOGIES RELATED TO HYBRID ELECTRIC VEHICLES WITH SPECIAL EMPHASIS ON PLUG-IN HYBRIDS

Hybrid electric vehicles (HEVs) and plug-in hybrids (PHEVs) require advanced technology in the areas of energy storage technology (batteries and/or electrochemical capacitors), motors and capacitors. These technology areas represent some of the most critical barriers to the development and marketing of cost-competitive HEVs and PHEVs. The Office of Energy Efficiency and Renewable Energy is interested in identifying and developing innovative concepts for advanced technologies to improve the performance, extend the life, and significantly reduce the cost of hybrid electric vehicles.

HEVs require energy storage devices that can deliver high power pulses. PHEVs will require devices that both store significant energy and can deliver high power pulses. All of these devices must be able to accept high power recharging pulses from regenerative braking. For HEV applications, the goal is to develop cells that provide peak power of 1200 W/kg or greater, have a cycle life of at least 300,000 shallow cycles, and have a calendar life of 15 years. PHEVs will require batteries that can deliver significant energy (several kWh) for several thousand discharge cycles from an almost full charge to a low state of charge. It has been suggested that a PHEV battery would operate in a charge depleting hybrid mode from about 90% of full charge to about 25% of full charge. Once the battery reaches this lower state of charge, it will function in a manner similar to the battery in an HEV and must be able to sustain 200,000 – 300,000 shallow cycles with a 15 year calendar life. For all systems, materials to be utilized should be plentiful, have low cost (< $10/kg), be environmentally benign, and be easily recycled. Evaluation of the technology with regard to the above criteria should be performed in accordance with applicable U.S. Advanced Battery Consortium test procedures or Society of Automotive Engineers recommended practices (see references that follow).

Advances in materials and designs for advanced electric motors, power electronics, and packaging are opening a variety of opportunities to significantly improve the performance, reliability, and economics of efficient energy use in transportation, buildings, industry, and renewable energy. These include new applications for the conversion of power from electrical to mechanical or mechanical to electrical forms; power electronics that can operate reliably at higher temperatures.

Grant applications must show how the proposed innovations would result in significant advances in performance and/or cost reduction over state-of-the-art technologies. Successful proposals will clearly demonstrate the ability of the applicants to proceed to more advanced stages of development; for motors

and power electronics, these stages include hardware development, fabrication, testing, and manufacture of components and devices.

Grant applications are sought only in the following subtopics:

a. New Materials to Improve the Performance of Lithium-Ion Batteries in HEV and PHEV Applications—Advances in battery performance often come in two stages: first there is the development of new materials for use in an electrochemical cell; then there is the optimization of how the cell is fabricated. In this model, new materials must come first. Most of the active materials now being used in advanced rechargeable batteries, such as the family of lithium-ion systems, have been known for some time. Many of the recent improvements in performance have come from relatively small adjustments in the chemical formulation or physical form of known materials. Some members of the technical community believe that new materials will be required to meet the cycling profiles of advanced HEVs and PHEVs while also meeting the goals for cost, calendar life, and other properties.

Grant applications are sought to identify, synthesize, and characterize novel materials for use as the active materials in advanced batteries for HEVs and/or PHEVs. Proposals in response to this subtopic may focus on materials associated with the positive electrode, negative electrode, and/or electrolyte. Existing materials may be used for components that are not under development. The new materials may fit within a current family of batteries, such as lithium-ion, or may represent a novel electrochemical system. Successful applications must clearly explain why the proposed materials are truly novel and discuss why the materials are expected to be able to meet the requirements of a vehicular battery. Materials that clearly can not meet vehicular requirements, such as those that require very expensive starting materials, are not appropriate. Preference will be given to applications that propose "out-of-the-box" materials and support that proposal with appropriate theory or available data. During Phase I, the new materials must be prepared and demonstrated by cycling in laboratory cells. In Phase II the material's properties should be refined, synthesized in repeatable batches, and characterized in cells of at least 200 mAh in size.

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

b. Improved Lower Cost Electrode Materials for Electrochemical Capacitors—The most common electrochemical capacitors, also known as "super" or "ultra" capacitors, use a form of carbon as the active material in both electrodes. The carbons which perform well (good capacitance, long cycle life, long calendar life, relatively little self discharge, etc.) tend to be quite expensive, costing over $50/kg. Carbons which cost less than $25/kg tend to exhibit one or more performance problems. The high cost of the materials that perform well is one of the limiting factors in the development and potential adoption of capacitors for vehicular applications. Novel grant applications are sought that will address the cost of electrode materials in either symmetric (both electrodes are of the same material) or asymmetric (electrodes with different materials) capacitors. Replacement materials that result in reduced performance relative to the state-of-the-art (in areas such as power capability, energy stored, operating temperature, useful life, or cost) are not of interest. All proposals must provide a clear discussion, based upon available data and theory, to support an assertion that the materials to be developed will offer acceptable performance at a lower cost. Grant applications must include a demonstration of the materials' performance in laboratory cells by the end of Phase I and in capacitors suitable for use in a vehicle by the end of Phase II.

Questions - contact Susan Rogers (susan.rogers@hq.doe.gov)

c. Technologies to Address Problems Associated with Internal Heating in Capacitors—Capacitors suitable for harsh automotive environments must suffer extreme environmental conditions. Film capacitors present an option for use as high voltage bus capacitors. However, they must accommodate high ripple currents, in a high temperature environment. There is a need for higher density lower resistivity foils to allow more ripple current capability with less heating. If a capacitor is going to be exposed to under-hood temperatures of up to 150ºC it is necessary for the capacitor to be capable of handling high current without the need for external cooling. The present design package of most film capacitors presents a heat dissipation problem in that the foil is wrapped so that the heat is dissipated more quickly in the axial direction. When internal heating is increased due to an increase in ripple current the capacitor could fail if that heat isn't removed quickly enough. New materials and designs that allow better heat transfer out of the capacitor to reduce internal heating problems and increase life expectancy.

Questions - contact Susan Rogers (susan.rogers@hq.doe.gov)

d. Technologies Associated with Advanced Motors—High-temperature, high-strength, lower-cost permanent magnets (PMs) are needed for traction motors for HEVs and PHEVs. The trend for higher-temperature electric machines requires higher-temperature PMs. The strength of the current NeFeB PMs is weakened significantly as temperature rises. Grant applications are sought to develop new magnetic materials to allow low cost, easily manufacturable permanent magnets with energy products comparable to what is commercially available today with sintered magnets at temperatures up to 240ºC.

Grant applications are sought to produce stator and rotor core as well as magnet material with increased resistivity to improve electric motor efficiency by reducing eddy currents and to reduce fabrication costs, even for complex shapes. The calculation of efficiency involves loss from windage, bearing friction, Joule heating in the copper wires, hysteresis in the core and stator, and eddy currents in the core, stator, and magnets. Eddy current losses are significant and reducing them will increase the efficiency of a motor. In all synchronous motors, the rotation of the magnetic field, which is produced by the stator windings and is in sync with the rotor, generates eddy currents in the stator core. Furthermore, the magnetic field pulses generated as the rotor magnets pass the openings between the stator teeth, generate eddy currents in the magnets. Eddy current density is inversely proportional to the resistivity of the core material and magnets. Power loss is proportional to the product of resistivity and the square of the eddy current density, which causes the eddy current power losses to be inversely proportional to the resistivity. Insulated laminated core material has conventionally been used to increase resistivity normal to the laminates in the stator and, more recently, an epoxy coating on magnetic particles, which are formed into "bonded" magnets, is being used to increase the resistivity of the magnets. The difficulty with conventional laminated materials is that many sheets must be punched and assembled to produce the final stator or core. The difficulty with the bonded magnets is that their remanence is lower than that of sintered magnets. Grant applications are sought to economically produce core material and magnet material with high resistivity that would improve motor efficiency and reduce fabrication costs. Such research could look for ways to coat particles, possibly nano-particles, with thin high resistance ceramic materials that do not break down during sintering. Particles could be structural as well as magnetic. Coated structural particles might be injection molded to

complex shapes and sintered to achieve final strength in place of laminates in the stator and core. Thin ceramic coatings on magnetic particles instead of epoxy coatings could increase the remanence while retaining low resistivity.

Questions - contact Susan Rogers (susan.rogers@hq.doe.gov)

References:

Subtopic a: New Materials to Improve the Performance of Lithium-Ion Batteries in HEV and PHEV Applications

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.

3. This site contains multiple references that summarize work supported by the FreedomCAR and Vehicle Technologies Program related to energy storage. Prior to 2002, there are separate publications for the Energy Storage Effort and for Advanced Technology Development. In more recent years, there is a combined report for Energy Storage. These reports include information about cell chemistries that have proven to be useful model systems for these applications along with discussions of issues related to abuse tolerance and cell life. (URL: http://www1.eere.energy.gov/vehiclesandfuels/. On menu at left, click on "Energy Storage".)

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

Subtopic b: Improved Lower Cost Electrode Materials for Electrochemical Capacitors and Subtopic c: Technologies to Address Problems Associated with Internal Heating in Capacitors

5. Efford, T., et al., "Development of Aluminum Electrolytic Capacitors for EV Inverter Applications," presented at the IEEE Industry Applications Society Annual Meeting, New Orleans, LA, October 5-9, 1997. http://ieeexplore.ieee.org/xpl/conferences.jsp

Subtopic d: Technologies Associated with Advanced Motors

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

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

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

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

10. Hendershot, J. R., Jr., and Miller, T. J. "Design of Brushless Permanent Magnet Motors," Chapter 16, Oxford: Magna Physics Publishing and Clarendon Press, 1994. This chapter contains a good discussion of eddy current and hysteresis core losses. (ISBN: 1-881855-03-1)

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

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

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

6. ALTERNATIVE FEEDSTOCKS TO CHEMICALS

The U.S. chemical industry used 6.4 quads of energy in 2004, 6.4% of the total U.S. energy consumption. Approximately 47% of this energy was used for fuel and power production, and 53% (3.4 quads) were used as feedstocks for production of thousands of industrial products including plastics, pharmaceuticals, electronic materials, and fertilizers. The chemical industry is the single largest user of natural gas, accounting for 10% of all U.S. natural gas consumption. Although coal, biomass, etc. can be used as hydrocarbon feedstocks, naptha, natural gas condensates, and natural gas account for 99% of the feedstock materials used by the chemical industry. Natural gas is predominately used to manufacture methanol and ammonia, and 70% of the U.S. olefins (particularly ethylene) production is based on natural gas condensates. As the U.S. supply of natural gas and natural gas condensate has

decreased and prices have risen in the 2000s, production of these chemicals has been transferred overseas. In 2004 about 50% of the U.S. methanol, 45% of the ammonia, and 15% of the ethylene capacity were shutdown, and the percentage transferred overseas has increased since that date. This has resulted in the U.S. chemical industry having a trade deficit for the first time in history, negatively impacting the U.S. GDP. The Nation must address growing environmental issues, supply issues, and energy prices in supplying energy in the future.

Efforts to increase industrial cost-competitiveness, boost energy efficiency, increase productivity, increase energy security, and prevent pollution demand will require that traditional chemical feedstocks (petroleum and natural gas) be supplemented with materials that are abundant in the U.S. In response to these needs, the Department of Energy is seeking the development of alternative feedstock pathways for large-scale commodity chemical production (i.e., produced in quantities greater than 1×10^6 tons/year). Near-term opportunities should focus on feedstock substitutions to make existing products with minimal changes in existing manufacturing facilities. Long-term opportunities will involve manufacture of new products involving new chemistries and potentially new processing equipment. Of particular interest are grant applications that offer the potential to improve the state of the art, be more cost effective than current techniques for producing alternative feedstocks, and be applicable to broad segments of the industry. Grant applications must address the potential public benefits that the proposed technology would provide from reduced consumption of petroleum and natural gas and from reduced pollutants. Analyses have shown that the most promising applications for broad benefit include the production of olefins (ethylene, propylene, and butadiene), aromatics (benzene, toluene, and xylene), paraffinic derivatives (mono ethylene glycol, mono propylene glycol, and propylene oxide), acetone, and formaldehyde from coal, biomass, and to a lesser extent from crude derived from oil shale and tar sands. Grant applications should include a review of the state-of-the-art of the targeted application in the U.S., including a review of current inefficiencies. Strategies to overcome these inefficiencies should be identified and practical means to address them developed. Approaches must demonstrate an attractive cost over a practical range of energy costs. The cost of applying the new technology and the ease of implementation are also important. **Grant applications are sought in the following subtopics only:**

a. Coal to Chemicals—Research has been funded for conversion of coal to fuels by gasification and liquefaction processes. However, much less research has been directed towards use of coal as a feedstock for large-scale chemical production. Grant applications are sought that build on power production research but address technical issues that are unique to production of alternative feedstocks. Improved separations are required to remove minor impurities that would not impact power generation but could negatively impact chemical production and byproduct formation. These include, but are not limited to, heavy metals and alkalis. Separations processes that minimize the generation of secondary waste and CO_2 are also of interest; emissions of SO_x, NO_x, mercury, and heavy elements should be minimized. The impact of coal composition on chemical production must be addressed, i.e. lignite, bituminous, versus sub-bituminous coal and sulfur content. Modification of the existing Fischer-Tropsch process for production of chemicals rather than fuels would be of interest. Processes that blend coal and biomass feedstocks would also be of interest.

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

b. Cellulose-Based Biomass to Chemicals—Research has been funded for conversion of biomass to liquid fuels via thermochemical gasification and fermentation. Some research has been funded by the

Department of Energy for production of small-volume chemicals via fermentation technology using sugar-based biomass feedstock. However, much less research has been directed towards use of biomass as a feedstock for large-scale chemical production. Grant applications are sought that address technical issues that are unique to production of alternative feedstocks for the production of commodity chemicals. Improved separations are required for pretreatment of cellulose, lignin, etc. and removal of byproducts to allow use as feedstocks. Cost effective scale-up methodologies for biologically-based processes must be developed to allow economic production of commodity chemicals. Of particular interest are fermentation technologies that produce feedstocks from cellulose-based biomass rather than starch and sugar-based materials, such as corn and sugar cane, which compete with food chain components. Development of new chemical pathways is needed (for example: alcohols to acids, aldehydes to acids, alcohols to aldehydes, acids to alcohols, dehydration to lactones and anhydrides) when starting from more oxidized material than petrochemicals.

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

c. Tar Sands and Heavy Oil to Chemicals—Research has been funded for conversion of heavy crude to liquid fuels. However, little research has been directed towards their use as a feedstock for large-scale chemical production. Grant applications are sought that address technical issues that are unique to production of alternative feedstocks. To date there has been very little research on the use of heavy oil, oil shale, tar sands or bituminous sands for chemicals production because these sources of oil have only recently become cost competitive with natural gas and oil. Heavy oil derived from tar sands has a higher aromatic content than conventional crude. The key aspect that needs to be addressed in the use of heavy oil for chemicals is the development of a ring opening catalyst to break down the polyaromatic tar compounds into smaller molecules, such as that used for selective cycloparaffinic ring opening. These catalysts must be resistant to impurities such as sulfur and nitrogen-containing compounds, and to coating with ultrafine particles. Chemical processes that minimize the use of hydrogen are desirable. Research of interest also includes blending of viscous, high molecular weight hydrocarbons from tar sands to adjust physical properties for use in chemical production.

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

References:

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

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

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

4. McFarlane, J., ed., "Survey of Alternative Feedstocks for the Chemical Industry," Draft: State-of-the-art literature survey performed by Oak Ridge National Laboratory for the Chemical Industry Vision2020 Technology Partnership, U.S. DOE Office of Energy Efficiency and Renewable Energy,

June 2006. (Full text available at: http://vision2020.chemicals.govtools.us/alternative%20feedstocks%20white%20paper.pdf)

5. McFarlane, J. and Robinson, S., "Alternative Feedstocks in Chemicals Manufacturing," presented at Green Chemistry and Green Engineering Conference, Washington, DC, June 27, 2006, U.S. DOE Oak Ridge National Laboratory, 2006. (Presentation slides available at: http://www.ornl.gov/~webworks/cppr/y2001/pres/124993.pdf)

PROGRAM AREA OVERVIEW
OFFICE OF BASIC ENERGY SCIENCES

The Basic Energy Sciences (BES) program supports fundamental research in the natural sciences leading to new and improved energy technologies. The program's purpose is to create new scientific knowledge by supporting basic, peer-reviewed research in areas of materials sciences, chemical sciences, geosciences, plant and microbial biosciences, and engineering sciences that are relevant to energy resources, production, conversion, and efficiency. The results of BES-supported research are routinely published in the open literature.

A key function of the program is to plan, construct, and operate premier national user facilities to serve researchers at universities, national laboratories, and industrial laboratories, thus enabling the acquisition of new knowledge that cannot be obtained in any other way. The scientific facilities include synchrotron radiation light sources, high-flux neutron sources, electron-beam microcharacterization centers, nanoscale science research centers, and specialized facilities such as the Combustion Research Facility. These national resources are available free of charge to all researchers based on the quality and importance of proposed nonproprietary experiments.

A major objective of the BES program is to promote the transfer of the results of our basic research to advance and create technologies important to Department of Energy (DOE) missions in areas of energy efficiency, renewable energy resources, improved use of fossil fuels, mitigation of the adverse impacts of energy production and use, and future nuclear energy sources. The following set of technical topics represents one important mechanism by which the BES program augments its system of university and laboratory research programs and integrates basic science, applied research, and development activities within the DOE.

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

7. CHEMICAL REACTIONS AND SEPARATION PROCESSES FOR BIO-REFINERY APPLICATIONS

This topic seeks R&D to address energy intensive chemical reactions and separation processes that will contribute to the success of the bio-refinery as a viable commercial alternative to the production of fuels and chemicals. For chemical processing, this topic emphasizes needs in catalysis, process intensification, and alternative reaction media. The goal of the separation process subtopic is the reduction of energy requirements of distillation either by further advance in distillation technology or through new separation processes that could be applied in a bio-refinery. As envisioned in the United States, bio-refineries will be used to make fuels and commodity chemicals on a large scale and will

mainly use feedstocks derived from cellulosic starting materials. Most of the commodity chemicals produced in the bio-refineries will be oxygenates. It is expected that both thermochemical and biocatalytic processes (enzymes) will be applied in bio-refineries. Grant applications are encouraged for innovation technology that will contribute to an energy-efficient bio-refinery, for which costs in processing are comparable to processes that use petroleum or natural gas feedstocks.

a. New Chemical Catalysts and Biocatalysts—All energy intensive chemical processes are included in this subtopic, for oxidations, reductions, substitutions, isomerizations. Grant applications are sought for the development of new chemical catalysts that derive their properties from special characteristics of nano-scale materials, or nano-scale functionality imparted to a material. Grant applications are sought for the development of both heterogeneous and homogeneous catalysts - with emphasis on the development of new catalysts for energy savings in the chemical and allied process industries. The development of new catalysts for the use of new feedstock materials for the production of commodity chemicals would also be responsive to this subtopic. Since there is a wealth of R&D on new catalytic materials, especially involving nano-scale materials with new catalytic properties, applicants are strongly encouraged to review the pertinent patent and scientific literature prior to submitting an application under this subtopic.

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

b. Process Intensificiation—Grant applications are sought to develop process intensification methodology for common chemical processes and bioprocesses. The new methodology should lead to lower process energy requirements or savings in feedstocks over processes that do not employ the methodology. For example, microchannel reactor technology can reduce the dilution volume needed for many chemical processes, thus reducing the energy requirements of separations. Microchannel reactor technology can also be used in the application of chemical catalysis with enhanced selectivity. For bioprocesses, process intensification methodology may reduce the water requirements of bioprocesses that do not use the methodology – reducing the energy requirements of bio-processing. In this subtopic, as in the first subtopic, scientific and patent literature must be carefully reviewed before submitting a grant application.

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

c. Alternative Reaction Media—Grant applications are sought for the development of reaction media for both chemical processes and bio-processes that will reduce the energy requirements of processing. For example, ionic liquids may reduce energy requirements of chemical processing by eliminating distillation steps – needed separations are accomplished by complexification or other means. For bio-processing, reaction media other than water may reduce energy requirements of water-based processes. The emphasis is on energy savings in the chemical industry and the bio-refinery industry in the manufacture of commodity chemicals.

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

d. Separation Process to Reduce or Eliminate Distillations—Grant applications are sought for innovative R&D of new separation processes for commodity chemical manufacture from typical feedstocks or bio-based feedstocks. This may include the development of new membrane process

technology, and alternative methods such as complexifications, and absorption. Responsive applications should demonstrate how the proposed separation technology will save energy that would be used for a needed distillation step. Many new separation technologies may find application in the manufacture of more than one commodity chemical product. Careful review of the pertinent scientific and patent literature is imperative to avoid the duplication of current or previous technology R&D.

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

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

8. CATALYSIS

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

Grant applications must address the potential public benefits that the proposed technology would provide from 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.

The industrial focus of this topic is the U.S. chemical and petroleum refining industries, using natural gas, natural gas liquids, and petroleum derivative feedstocks. "Chemical Industry" is taken here in the broadest sense - to include petroleum refining and primary chemical manufacturers and users of primary and intermediate chemicals for higher value products.

Grant applications are sought only in the following subtopics:

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

petroleum cracking in a fluidized bed, as well as new heterogeneous catalysts for alkene/alkane alkylation.

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

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

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

c. Reactive Separations—Grant applications are sought for the integration of catalysts with separation technologies for energy-efficient processing – such as reactive distillations and catalytic membranes. Grant applications for R&D that will overcome previously identified technical barriers to the use of reactive separation technologies in industry are especially desired. For example, the tendency of homogeneous catalysts to dissolve in reaction media limits the stability (and therefore the use) of homogeneous catalysts fixed to a membrane. Grant applications are also sought for the development of new reactive separation technologies, and reactive separation technologies that use innovative approaches to overcome technical barriers to the industrial use of reactive separation technology.

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

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9. SEPARATION PROCESS TECHNOLOGIES FOR MANUFACTURING

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 is seeking the development of high-risk, innovative separation technologies in processes for distillation, adsorption, and dewatering. Also sought are innovative separation processes that are applicable to biomass slurries. Grant applications must address the potential public benefits that the proposed technology would provide from reduced energy consumption and from the reduction of materials consumption, water consumption, and/or the dispersion of toxins and pollutants. 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. Distillation—Significant quantities of inorganic acids, and all commodity organic chemicals, are purified by distillation at some stage in their manufacture. Distillation accounts for more than 60% of the total process energy used for the manufacture of commodity chemicals and is therefore a meaningful

target for improvements in energy efficiency. Grant applications are sought to develop new technologies for significantly enhancing the energy efficiency of existing distillation systems used in the U.S. for the manufacture of any major commodity chemical, both inorganic and organic. Areas of interest include: (1) systems integration in commodity chemical manufacture that could be implemented at an attractive cost and reduces currently needed distillation capacity; (2) hybridization of distillation with other more efficient means of separation such as membranes – but before developing this approach, the history of commercial attempts to introduce efficient hybrid distillation systems should be carefully reviewed; (3) design and development of new column externals, such as the reboiler and the condenser, provided that the technology can be demonstrated at an acceptable cost and payback period; and (4) processes that take advantage of the excess reactive distillation capacity that may result from regulations on oxygenated fuel additives in the chemical industry, provided that the new processes enhance energy efficiency over the processes replaced.

Grant applications should include a review of the state-of-the-art of the targeted distillation application in the U.S., including a review of its current inefficiencies, in order to provide a sound technical basis for the efficiency gains to be expected from the technology development effort. Strategies to overcome the inefficiencies should be identified and practical means to address them developed. The number of distillation units in the U.S. that could apply the new technology should be identified, along with the energy savings that could be derived by reasonable market penetration. The cost of applying the new technology and the ease of implementation are also important. Approaches must demonstrate an attractive cost, maintain (or enhance) system reliability and safety, be capable of retrofit at attractive cost, and meet or exceed the performance characteristics demanded of distillation systems. Incremental improvements to existing distillation technologies are not of interest, nor is technology that is not broadly applicable to distillation as applied today in commodity chemical manufacture.

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

b. Adsorption—Adsorption uses special solids (called adsorbents) to remove substances from gaseous or liquid mixtures. Adsorption is effective for purifications, e.g. taking a contaminant ranging from 1 ppb to 1000 ppm out of a stream of gas or liquid. In addition, adsorption is good for bulk separations, e.g. taking 1 to 50% of a component out of a stream of gas, or maybe 1 to 10% out of a liquid. Adsorption is also used for the recovery of certain constituents (e.g., solvents from air), preventing pollution, separating impurities from natural gas, petrochemical separations, hydrogen purification, recovery and reuse of sulfur dioxide for metalcasting, and so on. Advances in, and the expanded use of, adsorption have resulted in substantial energy, environmental, and economic benefits in a number of industrial settings. One prominent example is in refineries and petrochemical plants, where pressure swing adsorption (PSA) has replaced cryogenic distillation as the most economical method for separating hydrogen from various compounds; by replacing cryogenic distillation with PSA, refineries and petrochemical plants have been able to reduce costs by anywhere from 60% to 90%.

Grant applications are sought in adsorbent and adsorption process development. The new adsorbents must have high capacity, rapid adsorption-desorption kinetics, improved selectivity, and operational stability at elevated temperatures in the presence of steam and other reaction components. The new adsorption processes must then take advantage of these new materials. Grant applications must address at least one of the following priorities: (1) development of high capacity CO_2 and CO selective adsorbents that can operate in the presence of hydrogen and steam at elevated temperatures (working

capacities in the range of 3-4 mol/kg are of particular interest), along with the development of new Pressure Swing Adsorption (PSA) or Temperature Swing Adsorption (TSA) cycle designs (possibly a PSA/TSA hybrid cycle design), at either ambient or elevated temperatures, that take advantage of these new adsorbents; (2) development of advanced structured adsorbent materials for use in rapid-cycle PSA, and further development of the design of rapid-cycle PSA; (3) development of novel PSA hybrid separation systems, e.g. with a structurally integrated permeable membrane; (4) CO_2 removal via TSA – development of TSA and/or PSA/TSA hybrid cycles with improved materials for use in H_2 separation technology and other applications; (5) improved hydrogen separations with Sorption Enhanced Reaction Processes (SERP), using a thermal swing regeneration and new materials – novel approaches, such as incorporating a high temperature reversible metal hydride as a H_2 selective adsorbent in a SERP to drive the equilibrium, should be considered; and (6) CO selective adsorbents.

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

c. Advanced Dewatering—The separation of water from a feedstock, product, or by-product stream is a common, often energy-intensive function in many industrial manufacturing processes. For example, dewatering processes in the pulp and paper industry, including paper forming and market pulp production, consume on the order of 4 -5 MMBtu/ton of product. Thermal dewatering techniques, while more effective than mechanical techniques for some systems (e.g., where there is a high solids content), require excessive space and capital in addition to consuming large quantities of energy.

Dewatering applications are also found in a variety of other industries including food processing, petroleum processing, agriculture, chemicals, and mining. The dewatering of citrus pulp and other food slurries is highly energy-intensive, as are many food drying processes and the dewatering of food crops and agricultural waste products. Applications in the chemical processing industries include dewatering of industrial sludges and chemical intermediates, as well as the dewatering required for oil/water separations and many other solid/liquid separations. In the mining industry, dewatering helps recover valuable minerals from ores, improve materials handling, process coal slurries, and reduce the amount of fine material entering waste streams. Novel dewatering techniques could also improve the ability to recover the iron contained in steelmaking sludges.

Grant applications are sought for breakthrough dewatering technologies that can dramatically lower energy consumption, improve energy intensity, and reduce the capital cost of equipment. In addition to improving many different processes within the manufacturing sector, advanced dewatering technologies also could provide benefits to the municipal wastewater and power production markets.

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

d. Recycling Automotive and Truck Materials—Innovative, lightweight materials are playing a key role in helping to improve vehicle fuel economy and safety. However, these materials can also present special challenges to recycling. Grant applications are sought to develop technology for the sustainable recycling of current and future automotive and truck materials. Grant applications must identify a specific issue and/or anticipated problem area(s) associated with the ability to recycle the material, and then outline a technical solution or approach for resolving the identified issue. Areas of interest include, but are not limited to, technologies for: (1) the separation and recovery of specific constituents from automotive materials (including shredder residue) that might otherwise be landfilled at end-of-life (e.g.,

improvements in mechanical separation technologies, development of advanced separation technologies such as high-speed materials identification and sorting, and the development of bulk physical separation processes including density and gravity separation, froth flotation, and electro-static processing); (2) the effective utilization and/or conversion of specific materials (or fractions of materials from shredder residue such as fines, polymer concentrates, etc.), which might otherwise be landfilled, to valued-added recycled products; (3) thermo-chemical conversion (e.g. pyrolysis, hydrolysis, gasification) of polymeric and other organic based automotive materials to saleable chemicals and fuels; and (4) the removal and control of residual contamination (by such substances as PCBs, PBDEs, and heavy metals) from materials recovered from shredder residue.

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

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2. "Vision 2020: 2000 Separations Roadmap," New York: AIChE, Center for Waste Reduction Technologies, 2000. (ISBN: 0-8169-0832-X) (Full text available at http://www.eere.energy.gov/industry/chemicals/pdfs/separations_roadmap.pdf)

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

5. "Biobased Industrial Products: Research and Commercialization Priorities," National Research Council Commission on Life Sciences, 2000. (Full text available at: http://newton.nap.edu/catalog/5295.html)

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10. NANOTECHNOLOGY APPLICATIONS FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY

The United States has made considerable investment in basic research in nanotechnology – with applications envisioned for medicine and health, National defense, electronics, and other areas. This topic solicits grant applications for innovative research in nanotechnology for energy efficiency and renewable energy – particularly, to enhance efficiency in the ways that energy is converted and used in the United States. Grant applications for "cross-cutting" uses of nanotechnology are especially encouraged – for example, the application of sensors and controls developed for Defense to a manufacturing industry for civilian applications. Grant applications must clearly demonstrate how the particular nanotechnology development will save energy in the end-use sector—Buildings, Industry, or Transportation, or in energy conversion and storage, including solar and wind energy conversion. This includes commodity manufacturing, building HVAC, lighting, refrigeration, power electronics, wind turbines, solar PV, solar thermal systems, high-temperature gas turbines, and technologies that will contribute to a hydrogen-based economy. The only stipulation is the enhancement of energy efficiency of existing technology must be through use of nanotechnology. The wider the application and the greater the potential energy benefits, the better.

a. Nanomaterials for Industrial and Building Applications—Grant applications are sought for nanomaterials for the enhancement of energy efficiency of the U.S. manufacturing and building sectors. By definition, nanomaterials derive unique properties from a structure or function imparted to a material within the physical dimensions of 1-10 nanometers. This can include materials with unique wear characteristics, high temperature characteristics, materials for improved manufacturing capabilities, as well as materials for improved building energy use in HVAC and lighting. "Cross-cutting" applications of new nanomaterials to the energy end-use sectors are especially encouraged.

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

b. Nanotechnology Applications in Electrons, Sensors, and Controls—Grant applications are sought for the development of electronics and sensors with application in the manufacturing industries, renewable energy conversion and storage, buildings, or vehicles. Since computer components and peripherals have become such large end users of electricity, grant applications for electronics and components for these applications are considered responsive as well. The only requirement is that nanotechnology is applied to save or make better use of energy in the end use. Numerous new nanotechnologies developed for Defense could be applied in making better use of energy for U.S. consumers.

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

c. Nanotechnology Applications in Renewable Energy Conversion—National programs for renewable energy development focus on solar energy conversion (especially photovoltaics), wind

energy, biomass power for utility applications, and hydrogen production and storage for transportation, including the development of fuel cell technology. Less emphasis is placed on geothermal energy and hydropower. Grant applications are sought for nanotechnology that will lead to better use or improved performance of any nationally emphasized renewable energy technology. The only requirement is that efficiency of the state of the art technology is improved through the application of nanotechnology. There has been extensive R&D in potential applications of nanotechnology for many of the invited technology areas such as photovoltaics, and therefore applicants must review technical and patent literature before submitting grant applications to this subtopic.

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

d. Nanotechnology Applications in Energy Storage—Grant applications are sought for R&D in nanotechnology for improved batteries that can be used in vehicles (especially lithium ion technology), hydrogen storage for use in vehicles, and other energy storage technology such as solar thermal energy storage for use on a utility scale. An example might be nanomaterials for use in negative electrodes of Lithium-ion cells. Lithium-ion cells represent the basic building blocks for batteries that range in size from those used in consumer electronics to those in the next generation of advanced hybrid electric vehicles (HEVs). Most lithium-ion cells in production today use some form of carbon (often a modified graphite) as the active material in the negative electrode (often called the anode). Most of these carbons are composed of relatively spherical particles several microns in diameter. A new family of electrode materials is now being reported in the technical literature. These materials have dimensions on the nanoscale and are often composed of elements other than carbon. Some materials, such as some alloys, perform poorly as electrode materials when they are prepared as relatively large particles but perform much better when synthesized as nanoparticles. Grant applications are sought to conduct research and development on new nanomaterials for use in the negative electrodes of lithium-ion cells that could be used in HEVs. Applications must provide a clear explanation as to why the materials are expected to function in a cell and why being composed of nanoparticles will offer performance benefits relative to current electrode materials. Applications must describe a viable path for the synthesis of these materials and discuss any issues associated with using them in batteries. To be attractive for use in applications such as advanced vehicles, materials must be inexpensive, environmentally benign, and be able to be charged and discharged at high rates for many cycles over a period of many years. (The specific performance goals for vehicular batteries are described in more detail in Topic 5.) In Phase I, successful projects will synthesize the materials in a reproducible manner, assess their chemical and physical properties, and demonstrate their performance in small lithium-ion cells. In Phase II, the synthetic methods should be refined to allow the production of the materials in larger quantities at a cost that is no more than that of the carbons currently in use. These quantities will be used to characterize the materials and confirm that they can be fabricated into practical electrodes (E.g. to confirm that the materials can be coated onto an appropriate substrate). In Phase II, the performance of the materials should be demonstrated in cells of at least 200 mAh in size. Grant applications must seek to apply nanotechnology for the improvement of a technology that is given a National priority, as described in the pertinent literature included in the references.

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

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

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11. ADVANCED COOLING TECHNOLOGY

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

Conventional air conditioners and refrigerators use mechanical vapor compression cycles for cooling. Although the refrigerant gas used today is now safe for the ozone layer, per the Montreal Protocol, it is a strong greenhouse gas. Per molecule, the refrigerant R-134a has 1300 times the direct Global Warming Potential of carbon dioxide over a 100-year period. Current vehicular air conditioners leak 10 to 70 grams of R134-a year; the European Union (EU) requires that new model cars introduced in 2011 and all new cars by 2017 not use R134-a. There are also large refrigerant losses from residential and commercial air conditioners and refrigerators. Overall, these and other halocarbons contribute about 0.34 W/m^2 of radiative forcing, as of 2000, which is nearly one-fourth of that due to CO_2 alone, at 1.46 W/m^2 (International Panel on Climate Change).

Given the large energy use for cooling and the use of hydrofluorocarbon refrigerants, both of which contribute significantly to global warming, there is a strong need for new cooling technologies that are

more energy efficient than current technologies and do not use refrigerants that contribute to global warming. New technologies that might be successfully developed for advanced cooling applications include (a) ThermoElectrics; (b) MagnetoCalorics; (c) ElectroCalorics; and (d) ThermoTunneling. Important contributory technologies also include advanced heat exchangers and advanced dehumidification technologies. These technologies should also be lighter, more compact, and more durable than conventional refrigeration technologies. Use of these technologies would also allow reconfiguration of system designs. For example, vehicles cooling systems would no longer be constrained to be positioned for belt-driven mechanical compression and could instead be placed where most convenient. Some of these technologies, particularly ThermoElectrics (TE), have long been used for cooling applications, but commercially available units typically have efficiencies of just one-fifth to one-tenth that of mechanical vapor compression cycles. Further advances in TE materials offer the potential for raising these efficiencies significantly above those of conventional mechanical systems.

In response to these needs, the Department of Energy is seeking the development of advanced technologies for space cooling in buildings and vehicles, and refrigeration for residential, commercial, and industrial applications. Technologies of interest will significantly reduce energy consumption compared to conventional mechanical vapor compression cycles and will eliminate use of refrigerants that provide a net contribution to global warming, while achieving costs at or below current levels for comparable systems. Grant applications must address the potential public benefits that the proposed technology would provide and should include a review of the state-of-the-art for both the technology application being targeted and the proposed technology. The ease of implementation for the proposed technology is also important. In Phase I, a preliminary design is required and the refrigeration cells should be defined with the best measurements available, including a description of the measurement methods used; the measurements should be within the state of the art. However, as such measurements can be extremely difficult, for example, with nanoscale thermoelectrics, the grantee may devise a test to show the cooling level with the power supplied. **Grant applications are sought only in the following subtopics:**

a. Buildings Refrigeration and Air Conditioning—Conventional air conditioners, heat pumps and refrigerators, which collectively use 5.3 quads of energy in the U.S., achieve cooling through a mechanical vapor compression cycle (VCC). Although the efficiency of the best VCC systems is on the order of 40–45% of Carnot efficiency, these efficiency numbers may be approaching asymptotic values, hence the opportunities for further improvements could be limited. Continuing progress in materials and manufacturing techniques may make advanced cooling technologies more attractive for building applications. Grant applications are sought for improved materials and manufacturing techniques that have the potential to provide improved cost vs. performance compared to conventional VCC technologies, with those that offer significantly improved efficiency being of greatest interest. However, due to market sensitivity to installation and reliability issues, technologies must also have the potential for very high reliability and be able to be installed without reliance on skill sets not commonly available in most communities. In order to be considered, a concept may address a particular segment of this broad applications area (e.g., commercial refrigeration).

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

b. Vehicular Air Conditioning—Grant applications are sought for vehicular air conditioning systems that must be able to withstand the accelerations, vibrations and temperature excursions typically

experienced in vehicle use in the U.S. in addition to meeting the above characteristics of improved energy efficiency and no use of refrigerants with net greenhouse gas impacts. The vehicles Heating, Ventilation and Air Conditioning (HVAC) system should be able to provide a nominal in cabin temperature of <70^{o}F with a worst case ambient temperature of 122^{o}F. It is strongly recommended that the respondent communicate with a vehicle OEM (Original Equipment Manufacturer) for vehicle specific desired heating and cooling loads, installation space and vehicle interface parameters. The grant application should include a first approximation road map with the major milestones from Preliminary Design to a Production Model of a Vehicular HVAC System. This road map would form the basis for a follow on project.

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

c. Industrial Process Refrigeration—Many techniques such as absorption chillers have been introduced into industrial processing to capture waste heat and use the heat for refrigeration or cooling. Grant applications are sought for the development and application of new materials to use industrial waste or secondary heat for refrigeration, as well as the development of new materials for refrigeration cycles for application in industry that will replace conventional refrigeration cycles based on ammonia and other refrigerants as the working fluid. "Industry" is taken here in the broadest sense, to cover manufacturing, food processing, and space cooling in large commercial applications. Grant applications are also sought to develop materials for refrigeration applications that will overcome current price/performance barriers to find wide spread application in industry. It is recognized that current barriers preventing solid-state materials from widespread application in industrial refrigeration are of such a magnitude that commercialization of the refrigeration technology for use in industry cannot be a near-term objective.

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

d. Utility and Industrial Heat Exchangers—In electrical utilities and in many process industries, improved heat transfer by heat exchangers represents the greatest potential for improving process energy efficiency. Grant applications are sought for improved heat exchanger efficiency using improved heat exchanger design, materials of construction, or both. Grant applications should characterize the target application, as well as analyze the potential benefits of the proposed new heat exchanger technology. Heat exchanger costs, ease of retrofit and installation, and maintenance must be given careful consideration to make the innovation technology commercially viable.

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

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12. SOLID-STATE LIGHTING (SSL)

The objective of this topic is to more fully engage small business in the application of key technologies to advance selected solid-state lighting (SSL) products to market. By overcoming technical and design challenges that today restrict the application of SSL to applications largely outside the realm of general illumination; the DOE hopes to further the performance parameters of this emerging technology.

Grant applications are sought to develop SSL products made from light emitting diodes (LEDs) and organic light emitting diodes (OLEDs), and off-grid SSL products. All applications must include: (1) a detailed product development plan that results in the introduction of a commercially viable product at the conclusion of Phase III; and a clear description of how the preliminary concept feasibility proven in Phase I will lead to a more advanced product developed during Phase II and ultimately, in commercialization during Phase III; and (2) a detailed energy conservation comparison that numerically illustrates exactly how the proposed product will offer an energy efficient alternative to a product currently serving the general illumination market within the U.S. commercial or residential buildings sector or on relevant properties. Preference will be given to commercialization plans that emphasize domestic manufacturing and/or use of domestic components and labor. Applications that fail to address all of the above criteria will not be considered for award.

Grant applications may also be submitted to address contributing scientific issues that are thought to limit the attainment of the DOE's goals for SSL. These applications need not include the detailed commercialization strategy required for product development proposals.

Grant applications are sought only in the following subtopics:

a. SSL Products made from Light Emitting Diodes (LEDs)—A wide variety of useful products such as traffic signals, emergency lighting, flashlights, key fobs, small display backlights and consumer electronics are presently manufactured that take advantage of the performance advancements made by LED manufacturers. While a few products such as task lights, under cabinet lighting or other niche applications are currently in the stream of U.S. commerce and are commercially viable general illumination products that, in some instances do save energy, these examples are few. Grant applications are sought to develop (1) low power, high light yield products; (2) high power, high brightness, high efficiency products; (3) low duty-cycle and/or monochromatic products; and (4) products that use combinations of different colors of LEDs to produce white light. Grant applications must seek to develop new technology that offers improved efficiency and better life cycle cost when compared to existing technologies.

Questions - contact James Brodrick (james.brodrick@hq.doe.gov)

b. SSL Products made from Organic Light Emitting Diodes (OLEDs)—Today, nearly all product applications for Organic Light Emitting Diodes (OLEDs), Phosphorescent OLEDs (PhOLEDs), Polymeric OLEDs (POLEDs), etc., are for small area displays such as cell phones, personal digital assistants (PDAs), vehicular audio systems or other consumer electronics. However, recent progress in OLED technology suggests that selected general illumination applications in U.S. buildings may be possible. While the emissive properties of OLEDs are distinctly different than for LEDs, the unique properties of OLEDs including low distributed brightness, unique color attributes and low power may be effectively used for energy conserving applications including, but not limited to emergency lighting, signage, night-lights or other conspicuity applications. Grant applications are sought to develop viable products that use any type of OLED for an application that might be included in U.S. buildings and that reduces lighting load either by reducing total luminous output by judicious choice of spectrum or any other method.

Questions - contact James Brodrick (james.brodrick@hq.doe.gov)

c. Off-Grid SSL Products—SSL devices have made a significant penetration into many product areas including general illumination applications. The unique, low voltage power requirements of these devices are an ideal match to leading photovoltaic (PV) devices that have exhibited similar advancements in market penetration and use. Combining these two leading emerging technologies to create useful products that do not use electric power supplied by the U.S. electric grid represents an ideal way to conserve power or to use these devices where grid power is simply not available or is of uncertain reliability. Even illumination devices that are not of sufficient efficiency to be considered for routine use in U.S. buildings may serve to save energy by providing service that is completely removed from the grid. While many useful products have already been introduced and are in fact, used daily (i.e., architectural and walkway lighting), there is ample room for new, imaginative product ideas that remove loads from the grid by shifting power requirements to a renewable source. Grant applications are sought for novel products that use a combination of SSL, PV, wind and batteries. Grant applications may include architectural facade lighting, remote outdoor lighting, marine applications, security illumination, emergency or portable lighting, or any other niche application that takes advantage of the unique properties of any or all of these emerging technologies. Grant applications are also sought that provide novel designs of practical devices that use Commercial Off-The-Shelf (COTS) technology for the SSL source, photovoltaic collection system, batteries and controls. The proposed devices should be cost competitive with the designs they replace and life cycle cost comparisons are required.

Questions - contact James Brodrick (james.brodrick@hq.doe.gov)

d. Contributing SSL Technology—DOE has identified a list of some of the contributing scientific issues that are thought to limit the attainment of the DOE's goals for SSL. Grant applications are sought to develop enabling technologies that (1) increase external quantum efficiency of LEDs and OLEDs, (2) improve thermal management and increase device performance of high brightness (HB) LEDs, or (3) improve device life-times for LEDs and OLEDs. Successful applications need not include the detailed commercialization strategy required for product development proposals. The end product of the proposed projects may be intellectual property that would be available for license to a third party or may support an existing business relationship with a manufacturing partner.

Grant applications are also sought to address one or more of the following issues only: (1) External quantum efficiency improvements: Internal quantum efficiencies of both LEDs and OLEDs are increasing rapidly to a point where out coupling or External Quantum Efficiency (EQE) is thought to limit the near-term manufacture of practical devices with high device efficacies. Grant applications are sought to explore and demonstrate novel, practical and manufacturable methods to increase EQE of selected materials systems. The chosen system must already possess a demonstrated high IQE and the application must seek to demonstrate the increase in device efficiency possible without making fundamental changes to the subject materials system or device architecture. Applications must succinctly describe the envisioned EQE increase and include a detailed plan showing exactly how the proof of principle will be made during the Phase I period of performance. (2) Thermal management for HB LEDs: High brightness LEDs that are generally used for general illumination applications are limited by how much heat can be conducted away from the chip and the package. Innovations in heat transfer strategies or materials used for substrates or packaging may provide chip and device designers the opportunity to create even more powerful devices that operate at higher current levels without suffering catastrophic thermal failures. Grant applications are sought for high thermal capacity or transport materials and films or higher temperature tolerant structures. Applications submitted to this subtopic must include a detailed, numeric estimate of the likely increase in device performance possible should the project demonstrate proof-of-concept. Theoretical model predictions are acceptable Phase I deliverables but development of advanced thermal models is not included here; and (3) Lifetime Issues (LEDs & OLEDs): HB LEDs and OLEDs intended for SSL possess limitations on lifetimes particularly when operated at high current densities required for general illumination applications but for very different technical reasons. For HB LEDs, thermal issues and phosphor degradation are the predominant mechanisms for device failure while for OLEDs, issues associated with contaminants and defects are thought to cause early failures. Grant applications are sought for the development of technologies that will improve device lifetimes. These may be unique materials or device designs or any other method by which improvements to practical device lifetimes will be achieved. Applications must include detailed lifetime estimates that identify specific mechanisms that will result in desired device lifetime improvements without compromise in efficacy or other performance metrics. Grant applications are also sought for the development of advanced theoretical knowledge or computational models that could be used by other researchers to advance devices with improved performance.

Questions - contact James Brodrick (james.brodrick@hq.doe.gov)

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13. NEUTRON AND ELECTRON BEAM INSTRUMENTATION

The Department of Energy supports a number of large-scale, national user facilities that provide intense beams of neutrons and electrons for the characterization of materials. **Grant applications are sought only in the following subtopics:**

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

Grant applications are sought to develop improved neutron detectors and associated electronics needed for DOE's existing and proposed steady-state and pulsed neutron scattering facilities (References 1-3). New detectors must represent substantial improvements in one or more of the following parameters:

efficiency at short wavelengths, high counting rate capability, high spatial resolution in one or two dimensions, time resolution (for pulsed source applications), cost per unit area, and adaptability to unique geometries. Detectors for pulsed neutron applications must be able to identify the time of arrival of each neutron. All detectors must have low intrinsic dark count rates and low sensitivity to gamma radiation.

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

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

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

Questions - contact Helen Kerch (helen.kerch@science.doe.gov)

b. Electron Beam Microcharacterization Facilities—The Department of Energy supports four collaborative research centers for electron beam microcharacterization of materials. These tools are important in the materials and biological sciences and are used in numerous research projects funded by the Department. Innovative instrumentation developments offer the promise of radically improving the capabilities of electron beam microcharacterization and thereby stimulating new innovations in materials science. Grant applications submitted to this subtopic must address improvements in electron beam instrumentation capabilities beyond the present state of the art.

Grant applications also are sought to develop stages, holders, and/or detectors with new capabilities for quantifying data and collection efficiency in electron beam instruments. Areas of interest include: (1) extremely stable holders and stages that allow long exposure/analysis times, with accurate tilting and alignment capability (to an angle accuracy ±0.005 degrees on two axes, while maintaining eucentricity to within 20 nm); (2) fast CCD camera systems that allow electron imaging exposure times in the millisecond range and kHz frame rates; (3) high sensitivity electron imaging systems based on CCD technology that provide 16 bit dynamic range or better over large areas; and (4) improved electron and x-ray detectors that are robust and not susceptible to electron beam damage. Proposed approaches for electron detectors must show suitability for either low- or high-energy electrons, and address one or more of the following three aspects: high quantum efficiency, high spatial resolution, and high temporal resolution. Proposed approaches for x-ray detectors should show significant improvement in sensitivity or spectral resolution for elemental analysis in electron microscopes.

Grant applications also are sought to develop stages and holders with new capabilities for *in situ* experiments or sample manipulation in the transmission electron microscope. Stages and/or holders must provide for one or more of the following: (1) application of magnetic field up to 5000 Oe in the plane of the specimen, with capability to rotate field orientation in the specimen plane with respect to the sample; (2) manipulation or measurement of the sample using a 4-probe nanomanipulator, including capability to measure deflection or strain, or capability to apply electric fields or current; and (3) precision control of specimen temperature (to an accuracy of 10^{o}C in the range 5-2000K), ambient gas pressure and flow rate (to within several percent for each), and alignment (to an angle accuracy ±0.005 degrees on two axes).

Grant applications also are sought to develop electron sources for scanning transmission electron microscopy with brightness on the order 10^9 Amp/cm^2/steradian or higher. Current sources are based on tungsten emitters, and it is hoped that higher brightness can be achieved with new materials and designs. Proposed electron sources must be suitably robust for practical applications, have long lifetimes (greater than 6 months), and offer a significant increase in brightness over existing sources.

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

Finally, grant applications are sought for extremely stable power supplies to improve lens stability in electron beam instruments. Power supplies should be capable of producing 15 amperes with current stability exceeding 0.1 ppm, or 5 amperes with current stability exceeding 0.05 ppm, and should exhibit voltage stability of 0.1 ppm in the range of 1 kV to 200kV.

Questions - contact Dean Miller (miller@anl.gov)

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14. TECHNOLOGY TO SUPPORT NATIONAL SCIENTIFIC USER FACILITIES

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future user facilities including the Spallation Neutron Source (SNS), the Linear Coherent Light Source (LCLS), and the National Sychrotron Light Source II (NSLSII). This topic seeks the development of technology to support these user facilities. **Grant applications are sought only in the following subtopics:**

a. Synchrotron Radiation Detectors—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. With advances in the brightness of synchrotron radiation sources, a wide gap has developed between the ability of these sources to deliver high photon fluxes and the ability of detectors to measure the resulting photon, electron, or ion signals. At the same time, advances in microelectronics engineering should make it possible to increase data rates by orders of magnitude, and to increase energy and spatial resolution. With the development of fourth-generation x-ray sources with femtosecond pulse durations, there will be a need for detectors with sub-picosecond time resolution. Therefore, grant applications are sought to develop new detectors for synchrotron radiation science across a broad range of applications. Areas of interest include: (1) area detectors for diffraction experiments; (2) area detectors for readout of electron and ion signals; (3) detectors capable of ultra-high temporal resolution; (4) high resolution imaging detectors; (5) detectors for high rate fluorescence spectroscopy; and (6) detectors for high energy fluorescence spectroscopy.

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

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5920, Bellingham, WA: SPIE, 2005. (ISBN: 0819459259) (Table of Contents available at: http://spie.org/app/Publications/. Search by Volume number.)

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

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

Grant applications are sought to develop diagnostics devices for measurement of electron beam emittance with high resolution. For free-electron laser (FEL) applications, electron bunch properties need to be measured with order of 10 μm resolution, such that the so-called "slice" properties may be determined with sufficient accuracy. The emittance of the beam is a critical parameter in FELs, and techniques for non-destructive measurements allow rapid and non-invasive tuning, as well as implementation of feedback systems for systems optimization. Possible concepts include optical techniques employing transition radiation or synchrotron radiation. The diagnostic should be small (< 1 m length scale) and integrate 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 are sought for development of diagnostics to measure energy spread within electron bunches, with resolution of order 10 μm. For free-electron laser (FEL) applications, electron bunch properties need to be measured with of order 10 μm resolution, such that the so-called "slice" properties may be determined with sufficient accuracy. The energy spread of the beam is a critical parameter in FELs, and techniques for accurate measurements would allow rapid tuning, as well as implementation of feedback systems for systems optimization. Possible concepts include optical techniques employing transition radiation or synchrotron radiation. The installed hardware should be small (< 1 m length scale) and integrate into an operational light source.

Finally, grant applications are sought to develop a diagnostic technique for the dynamic measurement of the transverse position of the centroid of an electron bunch, as a function of position along that bunch. The transverse wakefields in a linac may introduce the so-called "banana shape" beam as a result of the beam-break-up instability, in which deflecting wakefields introduce a transverse spatial offset in the electron distribution along a bunch. Proposed diagnostics must be able to measure this effect with spatial resolution on the order of 1 μm, and with temporal resolution (along the bunch) of 10-100 fs, in bunches of peak current 10-500 A.

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

Subtopic b References:

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

2. Roehrs, M., et al., "Time-Resolved Measurements Using a Transversely Deflecting RF-Structure," presented at 37th ICFA Advanced Beam Dynamics Workshop on Future Light Sources, Hamburg, Germany, May 15-19, 2006. (Abstract available at: http://spms.desy.de/pls/fls2006/search.author_list?letter=R. Scroll down to title.)

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

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

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

6. Smith, G. and Russo, T., "Proceedings of 10th Beam Instrumentation Workshop (BIW 2002)," Upton, New York, May 2002, American Institute of Physics (AIP), 2002. (ISBN: 0-7354-0103-9) (AIP conference Proceedings 648) (Table of contents and ordering information available at: http://proceedings.aip.org/proceedings/confproceed/648.jsp)

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

(1) Small gas bubbles to reduce beam-induced pressure. A population of small gas bubbles introduced in the mercury could absorb and attenuate the beam-induced pressure sufficiently to halt the driving mechanism for cavitation. The desired bubble size is approximately 10 μm in diameter and the required

void fraction approaches 1%. Grant applications are sought to develop: (1) techniques for generating this population of bubbles in mercury; and (2) credible diagnostics to quantify the generated population.

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

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

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

Subtopic c References:

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

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

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

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

d. Instrumentation for Ultrafast X-ray Science—The Department of Energy seeks to advance ultrafast science dealing with physical phenomena that occur in the range of one-trillionth of a second (one picosecond) to less than one-quadrillionth of a second (one femtosecond). The physical phenomena motivating this subtopic include the direct observation of the formation and breaking of chemical bonds, and structural rearrangements in both isolated molecules and the condensed phase. These phenomena are typically probed using extremely short pulses of laser light. Ultrafast technology

also would be applicable in other fields, including atomic and molecular physics, chemistry and chemical biology, coherent control of chemical reactions, materials sciences, magnetic- and electric field phenomena, optics, and laser engineering.

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

Questions - contact Michael Casassa (michael.casassa@science.doe.gov)

Subtopic d References:

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

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

3. Kapteyn, H. C., et al., "Extreme Nonlinear Optics: Coherent X Rays from Lasers," *Physics Today*, 58: 39, 2005. (Full text available at: http://jilawww.colorado.edu/kmgroup/papers/HK_PhysicsToday_0305.pdf)

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

5. Jiang, Y., et al., "Generation of Ultrashort Hard-X-ray Pulses with Tabletop Laser Systems at a 2-kHz Repetition Rate," Journal of the Optical Society of America, B20: 229 – 237, 2003. (Full text available at: http://www.rosepetruck.chem.brown.edu/Publications/Papers/03_JOSA_B_20_p229_Y_Jiang.pdf)

6. Seres, J., et al., "Source of Coherent Kiloelectronvolt X-Rays," *Nature*, 433: 596, 2005. (ISSN: b0028-0836)

15. ACCELERATOR TECHNOLOGIES FOR PRESENT AND FUTURE ACCELERATOR FACILITIES

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future user facilities including the Spallation Neutron Source (SNS), the Linear Coherent Light Source (LCLS), and the National Synchrotron Light Source II (NSLSII). This topic seeks the development of technology to enhance the operation of current facilities and to provide for optimal performance of the new 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 specifically 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 Basic Energy Sciences accelerator facilities, including, but 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 Experimental Physics and Industrial Control System (EPICS) suite of tools, in order to better support existing facilities and meet the requirements of future machines. Topics 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 the scalability to very large installations (such as the International Linear Collider). Grant applications should address how the results will guide long-term EPICS development.

Finally, as the time scale of interest in modern accelerators is reduced, the required computational resources are becoming prohibitive for currently-available low-order electromagnetic codes; for example, the estimated memory requirements for modeling a typical accelerator structure interacting with a 1-ps bunch is 1 TB. Such an extreme computation is intractable for most accelerator laboratories. Therefore, in order to break the computational bottleneck, grant applications are sought to develop computational electromagnetic codes with high-order accuracy.

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

Subtopic a References:

1. Bisognano, J. J. and Mondelli, A. A., eds., "Computational Accelerator Physics," Williamsburg, VA, September 24-27, 1996, American Institute of Physics (AIP), May 1997. (AIP Conference Proceedings No. 391) (ISBN: 1-56396-671-9)

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

3. Ko, K., "High Performance Computing in Accelerator Physics," Proceedings of 18th Annual Review of Progress in Applied Computational Electromagnetics: ACES-2002, Monterey, CA March 18-22,

2002. (Full text available at: http://www-group.slac.stanford.edu/acd/Computers2.html#)

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

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

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

b. Radio Frequency (RF) Devices and Components—With respect to high level RF accelerator systems, grant applications are sought to develop: (1) a high-level amplitude and phase modulator (in either waveguide or coaxial topology) that can demonstrate modulation ability out to 20 kHz – significant cost savings could be achieved if one klystron were used to drive multiple accelerating cavities, while retaining phase and amplitude control at the individual cavity level; (2) a variable input coupler for normal conducting (NC) and superconducting (SC) RF cavities – approaches must demonstrate a significant increase in mechanical complexity compared with fixed coupler designs, and provide for adjustments of the input coupler beta *in situ* in order to optimize the RF system efficiency; (3) a high-efficiency-switching high-voltage power supply for next generation RF accelerator systems, which will need cleaner HV DC power on RF amplifier devices to create less phase and amplitude jitter on the RF output – regulation of line power ripple must be achieved at the 0.5% level; and (4) Higher order mode (HOM) inductive output tube (IOT) continuous wave (CW) amplifiers at 350 MHz (tunable over a reasonable range would be desirable) at two power levels: 1 MW CW (applicable to the case where one amplifier drives several cavities) and 200 kW CW (in the case where each cavity has its own amplifier) – such a device could provide lower operating voltage, smaller size, and lower operating cost (approximately 15-20% higher efficiency over current klystrons). The potential energy cost savings with an IOT that could operate at ~70% efficiency (television IOTs approach that now with depressed collectors) would be significant. Making the IOTs tunable over a reasonable range would be a desirable feature also.

With respect to low level RF accelerator systems, grant applications are sought to develop: (1) an RF phase detector that can provide accurate measurements of phase jitter down to 0.01° (needed at several accelerator facilities, e.g. the LCLS and future ultra-short x-ray capabilities at APS) and an independent accurate measurement of the result of LLRF control (when the accelerator beam itself is used to determine RF system performance, facility commissioning is difficult); and (2) 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).

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

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

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

Subtopic b References:

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

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

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

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

c. Superconducting Technology for Accelerators—Complete 476 MHz superconducting RF systems are needed for present and future storage ring applications. Grant applications are sought to develop: (1) a single-cell 476 MHz superconducting RF cavity that can support 2A CW operation, provide more than 2 MW energy gain with field gradient excess of more than 10 MV/m, and have a loaded Q higher than 10^8 at 4.5 k; (2) a RF power coupler capable of handling 500 kW cw RF power; and (3) digital, low-level RF systems to control the phase and amplitude of superconducting RF cavities operating at 476 MHz, with loaded Q-values in the range of 10^8 – of particular interest are systems capable of phase control at the level 2^o or better, and amplitude control at the level of 1% or better.

In addition, with the successful implementation of superconducting radiofrequency accelerating structures at facilities in all regions of the world, additional emphasis is being placed on reducing superconducting radiofrequency (SRF) cryomodule costs and improving manufacturing quality. Therefore, grant applications are sought for innovative concepts and design approaches to the manufacture of cryomodule assemblies containing multiple-processed SRF cavities. Approaches of interest include new cavity cooling and support systems, reliable cavity tuners and tuner components, and less expensive fundamental couple assemblies.

Finally, a fundamental conceptual issue has arisen concerning the cooling of superconducting linacs during high-power pulsed operation. At fast pulse (1 ms), high-average forward-power levels (~ 75 kW), excessive thermal radiation loads from the fundamental couplers result in high couple surface temperatures, which reduce cavity stability and operating accelerating gradients. Therefore, grant applications are sought to develop innovative cooling concepts for fundamental power couplers, which do not impact the performance of the associated superconducting cavities.

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

Subtopic c References:

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

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

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

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

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

d. Advanced Sources for Accelerators—Grant applications are sought to develop: novel electron gun features including (1) robust materials suitable for production of low emittance electron bunches at high repetition rate using laser excitation. Intrinsic normalized emittance of the electron beam must be of order 10^{-7} m-mrad, in bunches of order 100 pC charge, duration of approximately 10 ps, and with quantum efficiency of 10^{-2} or greater. Materials should be robust to environmental conditions, have small dark current under applied electric fields of order 10-100 MVm^{-1}, and have long lifetime;(2) high power laser oscillator systems for high repetition rate(1-100 MHz) electron guns delivering pulses of 10-100 μJ energy in the 1 μm wavelength range, with pulses capable of being expanded to10-50 ps

duration; and (3) accelerating structures supporting electric fields of 10-100 MVm^{-1} at a cathode surface, allowing laser excitation of the cathode material and rapid acceleration of the emitted electrons with minimal emittance growth, and with electron bunch repetition rate of 1 MHz or greater. Combined with suitable cathode materials and photocathode laser system, the system should be capable of producing low emittance (less than 1 mm-mrad normalized) electron bunches at a minimum 1 MHz repetition rate, and up to 1 nC charge per bunch.

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

Finally, advanced undulator radiation sources are required for current and future light sources. Grant applications are sought for the development of: (1) superconducting undulators to generate tunable, monochromatic x-ray beams in the 2 - 30 keV photon energy range from medium-energy (2 - 3 GeV) synchrotrons. This requires undulators with short period (around 1.5 cm) and high peak magnetic fields (around 1.6 tesla). 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 SCU's which promise to meet these requirements. However, current designs suffer from inability to operate without quenching in the presence of the heat induced by the stored electron beam current and by synchrotron radiation encountered in modern synchrotron light sources. This heat load can be up to 100 watts per meter of undulator length. Novel ideas of SCU design, construction and thermal management to meet these challenging requirements; (2) undulators with period < 1 cm. The resonant condition for undulator radiation at short wavelength (approximately 1 nm), with low energy electron beams (of 1-2 GeV), requires undulators with period shorter than generally available on existing synchrotron radiation sources. Undulator designs with K-value ~1, impedance shielding of pole faces, and gap of greater than 2.25 mm.

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

Subtopic d References:

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

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

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

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

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

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

16. MATERIALS FOR ADVANCED NUCLEAR ENERGY SYSTEMS

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

a. Advanced Radiation Resistance Ferritic-Martensitic Alloys—Because of their resistance to void swelling, 9 Cr and 12 Cr ferritic-martensitic steels are considered prime candidates for intermediate temperature reactors such as the proposed liquid metal concept operating in the temperature range of 400-750°C. However, many ferritic-martensitic steels are limited by poor higher temperature creep strength, typically degrading at temperatures greater than 550-600°C (reference 6). Grant applications are sought to improve the creep strength of 9 Cr and 12 Cr ferritic-martensitic steels through alloying, dispersion strengthening, or precipitation hardening. Innovative alloys with protective coatings are also of interest. Proposed approaches must provide for (1) isotropic creep properties with strength greater than that of Sandvik HT9 steel, (2) a ductile to brittle transition temperature less than room temperature, and (3) a minimum plane-strain fracture toughness of $0.25\sigma_y$. Alloying elements that act as neutron poisons (e.g., boron) or that become highly activated in a neutron spectrum (e.g., cobalt) must be minimized or eliminated. Because the ferritic-martensitic steels likely would be used in conjunction with a sodium-cooled reactor concept, approaches that optimize corrosion performance while achieving improved high temperature strength would be considered high priority. Lastly, approaches that also address irradiation performance are strongly encouraged.

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

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

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

References:

1. "Generation IV Nuclear Energy Systems," U.S. DOE Office of Nuclear Energy, Science and Technology Website. (URL: http://gen-iv.ne.doe.gov)

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

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17. ADVANCED COAL RESEARCH

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from fossil 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.

a. Hydrogen Production from Coal—Clean forms of energy are needed to support sustainable global economic growth while mitigating greenhouse gas emissions and impacts on air quality. Hydrogen systems can provide viable, sustainable options for meeting the world's energy requirements. In the long-term, research will improve technology that will lower the cost to produce hydrogen from fossil fuels and also enable sequestration of carbon dioxide. Grant applications are sought for economical conversion of coal into hydrogen. Proposals must show clear economic advantages over the existing state of the art.

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

b. Potential for Sequestration of Greenhouse Gas Emissions and Enhanced Methane Recovery in Coalbeds—Previous and on-going work sponsored by the U.S. Department of Energy has focused on carbon dioxide and nitrogen injection into coalbeds for the purpose of storing CO_2 and enhancing coalbed methane production. For multi-component flue gas from fossil fuel power plants and other significant sources of greenhouse gas (GHG) emissions including landfill gas (LFG), there is an economic incentive to inject a greater fraction of the GHG-containing emissions into unmineable coalbeds, thus reducing costly separation efforts for CO_2, nitrogen, or other gases and creating the possibility of removing and sequestering other oxides (nitrogen and sulfur) from the flue gas by adsorption on the coal. Grant applications are sought to develop practical methods to (1) accelerate the state-of-the-science to inject greater volumes of flue gas or LFG into unmineable coalbeds; (2) develop advanced schemes for efficiently and economically capturing, separating, and injecting maximum volumes of GHG-containing emissions from power plants, industrial furnaces, and land fills; (3) address the practical problems from corrosion and other possible negative effects of injecting greater fractions of the total flue gas or LFG; (4) evaluate smaller potential coalbed methane resources for local or regional use; and (5) recommend at least one candidate scheme/approach for viability of commercial-scale testing by industry.

Questions - contact Frank Ferrell (frank.ferrell@hq.doe.gov)

c. Intermediate Temperature Solid Oxide Fuel Cell Cathode Enhancement through Infiltration Fabrication Techniques—Research is sought that employs infiltration processing techniques to

develop enhanced performance solid oxide fuel cell (SOFC) cathodes operating at intermediate temperatures (600^{o} to 700^{o}C). This might involve new materials infiltrated to provide catalytic enhancement or new nano-structures that enhance the transport and surface activity of existing materials. Grant applications should include a description of how an anticipated structure will lead to enhanced performance and how all of the required functionality of the cathode (such as current collection, gas transport, reaction site density) will be provided.

Background:

SOFC cathodes consist of an optimized structure involving ion, electron, and gas conduction paths. The nexus of these paths results in electrochemical charge transfer yielding a steadily polarized electrode which drives the electrical current through the external power load. The charge transfer process can be enhanced by a high density of reaction sites, by catalytic activation of reaction species, and by high conductivity to and from the reaction sites of all species involved.

High performance cathodes to date involve a heterogeneous mixture of materials in a combination that provides all of the necessary transport and reaction functions. The industry standard for 800^{o}C SOFC operation is a porous composite structure of electrically conducting La/Sr/Mn oxide (LSM) and ionically conducting Y/Zr oxide (YSZ). The active layer nearest the electrolyte surface consists of sub-micron particles and pores which create a network of "triple phase boundary regions" (tpb) where charge transfer can readily occur.

Undesirable chemical reactions between the different materials in such a composite structure can occur during high temperature processing and limit the ability to use more catalytically active materials. The LSM/YSZ tpb is a compromise between charge transfer activity and chemical stability. Other materials, those with the highest concentration of surface oxygen vacancies and the highest kinetics for rapid surface oxygen exchange, also seem to be the least chemically stable during high temperature processing and operation.

An alternative to co-sintering of particles in the composite is to first process a porous sintered support structure at higher sintering temperatures and then create active nano-structural additions and modifications through chemical infiltration and oxidation processing at reduced temperatures. In this manner, unique microstructures can be created and deleterious interfacial reactions avoided. (See presentations from the most recent SECA core technology workshop, http://www.netl.doe.gov/seca/workshop.html.) If the resulting cathode has an increased electrochemical activity and a lower overall area specific resistance, then it may be possible to operate at lower temperatures and provide for increased chemical and structural stability of not only the cathode but also the other components of the oxidation chamber.

Questions - contact Lane Wilson (lane.wilson@netl.doe.gov)

d. Coal-to-Liquids (CTL) Catalyst Development—As oil prices continue to rise, fuels from sources such as biomass or coal once again appear attractive. The role of the catalyst is to hasten those CO hydrogenation reactions for the desired products, avoid wide varieties of competing reactions, lower temperature and pressure, and maintain activity and selectivity in stable operation for long periods of time. In some cases, in addition to CO hydrogenation, accelerating the water gas reaction is also

desired. Bio-catalysis may find an application for the conversion of syngas to fuels. A preliminary evaluation indicated that microorganisms could produce alcohols (up to C_3), acetic/propionic acid and acetone from syngas. Preliminary results with some strains showed slow CO conversion to alcohols (40%) predominately ethanol.

Grant applications are sought for catalytic improvements that could contribute significantly to more economical manufacturing of synthetic liquid fuels from coal-derived syngas such as:

- Catalysts, which have higher selectivity to molecular species, which are useful as high performance fuels. For hydrocarbons, this means conversion, preferably in one step, to high octane gasoline components, namely isoparaffins and aromatics, or to olefins, which can be converted to liquid fuels. For oxygenates, this means octane enhancing ethanol or higher mixed alcohols.
- Catalysts, which eliminate or greatly reduce methane formation, particularly in the FT process or higher alcohol manufacture.
- Catalysts, which provide for operation of process modes, which are engineered to improve plant investment and operating costs, e.g., catalytic slurry system which can control heat release and decrease requirements for syngas recycle.
- Catalyst systems capable of providing for process integration for better efficiency.
- Catalysts with higher stability, resistant to deactivation by carbon deposition or by sulfur or halides.

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

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PROGRAM AREA OVERVIEW
OFFICE OF FOSSIL ENERGY

Fossil energy plays a key role in our Nation's prosperity, and it is important that we secure an adequate energy supply from our coal, natural gas, and oil resources. However, national complacency, derived from low-cost imported oil, has allowed petroleum imports to increase to alarming levels. We need not go far back in history to find out how uncertainty in petroleum supply can affect our Nation's economic growth. Nonetheless, our near term power generation, heating, and transportation needs still require the utilization of these hydrocarbon-based fuels. As the economy expands, demand for hydrocarbons will increase accordingly. Therefore, the Office of Fossil Energy seeks to develop advanced fossil energy technologies that are environmentally sound and economically competitive.

Technological innovation is required to take advantage of the United States' large supply of coal and natural gas reserves. Coal's major drawback is that it contains sulfur, nitrogen, mercury, and other trace heavy metals, precursors of pollutants that could have deleterious effects on the environment. Also, natural gas is produced with a wide variety of pollutant-forming compounds, which preclude some applications such as fuel cells. For both coal and natural gas, further improvements are needed to develop advanced, low cost, high-efficiency processes for the production of clean energy. In addition, it is prudent to consider ways to reduce carbon dioxide and other greenhouse gases that are generated by the combustion of fossil fuels, to investigate carbon sequestration in geological and other systems, to consider hydrogen as an alternate fuel, and to mitigate impacts on water resources. Advanced technology development in materials that assure compatibility with advances in power systems – as well

as innovations in fuel cells, measurements, sensors, monitors, and controls – will be needed for these technologies to be commercially competitive.

Improvements are also needed in our ability to recover both oil and natural gas. About two-thirds of our national petroleum reserve is "unrecoverable"; i.e., it cannot be extracted economically by conventional means. This unused resource could play a major role in supplementing the national petroleum supply if efficient approaches were developed for improved extraction. Natural gas production and utilization could also be increased through improved characterization of reserves and through better infrastructure.

The following topics seek the participation of small businesses in addressing problems related to utilization of coal and natural gas to produce power, and to the recovery of oil and natural gas. Many of the topic offerings indirectly support the DOE's FutureGen initiative, a program to demonstrate hydrogen production and carbon sequestration. The objectives of FutureGen are to produce hydrogen at $4/MMBtu, sequester 100% of the carbon-dioxide, and produce electricity with zero emissions at less than a 10% increase in cost.

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

18. COAL GASIFICATION AND COMBUSTION TECHNOLOGIES

Coal gasification offers a versatile and clean way to convert the energy content of coal into electricity, hydrogen, other high quality transportation fuels, as well as high-value chemicals to meet specific market needs. Most importantly, in a time of electricity and fuel price spikes, flexible gasification systems can provide a capability to operate on low-cost, widely-available feedstocks. Furthermore, gasification may be one of the best ways to produce clean liquid fuels from coal, and clean-burning hydrogen for tomorrow's automobiles and power-generating fuel cells. Hydrogen and other coal-derived gases also can be used to fuel power-generating turbines or used as chemical "building blocks" for a wide range of commercial products. The DOE Office of Fossil Energy is working on coal gasifier technology advances that enhance efficiency, environmental performance, and reliability.

In addition, new materials, ideas, and concepts are required to significantly improve performance and reduce the costs of existing fossil systems or to enable the development of new systems and capabilities. The Fossil Energy Materials Program conducts research and development on high-performance materials for longer-term fossil energy applications, including gas separations and storage. The program is concerned with operation in the hostile conditions created when fossil fuels are converted to energy. These conditions include high temperatures, elevated pressures, and corrosive environments (reducing conditions, gaseous alkali). **Grant applications are sought only for the following subtopics:**

a. High Temperature Heat Recovery Integrated Gasification Combined Cycle (IGCC)—The National Energy Technology Laboratory's Clean Coal Technology program includes 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). Both IGCC 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. Steam from the HTHRU is superheated by the gas turbine heat recovery system for power generation. Major components of the Wabash syngas cooling/steam generation system are the firetube heat recovery boiler and the high-pressure steam drum. Ash deposits have occurred in the HTHRU and have created operational difficulties and caused high system pressure drops. 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 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". 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 is around 1050°F. 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. The CSC system consists of 6 heat exchangers with associated interconnecting piping. Each one is a fire-tube shell and tube heat exchanger. Syngas leaves 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 was identified as a major problem resulting in 478 unplanned outage hours, more than any other equipment at the station. Heat exchanger fouling and subsequent plugging and/or erosion are major contributors to lowering IGCC avail ability.

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)

b. Novel Concepts in Industrial Gasification—Natural gas is used as a feedstock in many industries in addition to the power production industry. However, the increasing cost of natural gas, along with the likelihood that the cost will continue to increase, is driving the development of new technologies to improve the economic return for coal gasification processes outside that of power production. Therefore, grant applications are sought to develop novel technologies to make gasification, from a feedstock of at least 75% coal, more attractive for industrial use, including the production of synthesis gas, hydrogen or substitute natural gas (SNG). New or revisited gasification concepts, e.g., hydro-, or catalytic gasification are encouraged. Target industries include small utility, metals, chemicals, pulp and paper, and glass. Proposed approaches should demonstrate a significant impact on the chosen industry or industries – the larger the niche for the gasification process, the better. The proposed novel technology and overall process may be for either near term or long term deployment into industry. DOE envisions that the industrial applications scale would be in the 25 to 100 MWe equivalent range.

Grant applications are sought to: address optimizing the gasifier operating conditions for a specific industrial application. For example, for hydrogen/SNG production, the operating conditions and design characteristics that might reasonably be expected to influence the methane and/or hydrogen content include: pressure; temperature; feed media and system (dry vs. wet slurry with water); residence time and internal or external recirculation/recycle rates; sizing of reaction chamber; feed rates of oxidant or steam; particle sizing; feed injector mixing patterns; number and design of gasification stages; internal/external shift reaction catalysts; and internal separation mechanisms, such as sorbents and/or membranes. Process operating conditions that can 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. Limited modeling to support experimental work is acceptable, but grant applications that involve extended, idealistic modeling of gasification systems, without supporting experimental data, are not of interest.

Grant applications must also: (1) define the products of the gasification process and show whether they will be exported, used within the plant, or a combination of each – it is not necessary for power to be one of the products, although it may be; and (2) include in Phase I an analysis of plant thermal efficiency and economics, in comparison to competing technologies.

Questions – contact Elaine Everitt (Elaine.everitt@netl.doe.gov)

c. Novel Concepts in Hydrogen Production and Process Intensification—The DOE's FutureGen project, now in its early planning stage, aims to demonstrate the technical/economical feasibility of a coal gasification plant to produce power, with near-zero emissions including the emission of carbon dioxide. The strategy is to convert coal to hydrogen that would be used as fuel for fuel cells and/or gas turbines, with the concurrent sequestering of the concentrated carbon dioxide from the processing and power blocks. Under this scheme, coal first would be gasified to produce synthesis gas (mainly hydrogen and carbon monoxide). This would be followed by processes for removing impurities and producing additional hydrogen through the water-gas-shift reaction. Finally, the hydrogen would be separated from other compounds.

Hydrogen has the potential to be used in a number of end-use applications each having its own purity standards. New materials and processes are necessary to remove trace quantities of impurities such as CO, N_2, S, metals, and other impurities to manufacture high purity hydrogen for a variety of applications. Therefore, grant applications are sought to develop advanced processes, materials and devices for producing ultra-pure hydrogen from coal-derived synthesis gas. While, the primary interest is processes that remove all impurities,

Grant applications should demonstrate: familiarity with end-use purity specifications and ensure that the level of hydrogen purity provided by the proposed concept matches the appropriate end-use (i.e., hydrogen turbines, fuel cell, modified internal combustion engines).

Process Intensification through the development of advanced technologies that offer the potential to consolidate two or more unit processes/unit operations in one module could provide higher efficiencies, lower capital costs and a smaller overall footprint for the coal-to-hydrogen plant. One such example is the combination of water-gas-shift and hydrogen separation into a single step, carried out at

temperatures compatible with the synthesis gas that exits from the cleanup step. (Current development work shows that clean syngas can be produced in the 350^{o}C to 400^{o}C range.)

Grant applications are sought to: develop novel processes that may be located inside the gasifier as well as those located outside the gasifier to produce a syngas with high hydrogen content (>70% by vol.). Proposed approaches should provide robust performance; high hydrogen throughput, selectivity, and recovery; long system life; and low operating cost. These new technologies should be able to operate at pressures compatible with gasifier pressures up to 1000 psig. In addition, they should have high tolerance for the low levels of sulfur and the other impurities that are present in feed gas. Grant applications should demonstrate familiarity with current commercial technologies to produce hydrogen from coal, as well as with the ongoing R&D supported by DOE in the coal-to-hydrogen program.

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

d. Hydrogen and Syngas, Novel Concepts in Liquid Fuels Production and Process Intensification with Carbon Management—The United States' economy is inextricably linked to liquid fuels to sustain its large transportation sector. These liquid fuels are largely derived from crude oil, but world crude oil prices have skyrocketed from around $10 per barrel to over $60 per barrel within the past seven years. Consequently, 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 few candidate resources to produce liquid fuels include biomass, oil sands, oil shale, and coal, but coal is the most promising resource with over 250 billion tons of known reserves.

Coal-derived liquid fuels produced via Fischer-Tropsch (FT) processes are fungible with the existing petroleum distribution, storage, and end-use infrastructure. Furthermore, these fuels are zero-sulfur paraffinic hydrocarbons that are similar to diesel with a high cetane number (~75) compared to petroleum diesel (~45). This provides for efficient operation in high-pressure compression-ignition engines and reduced particulate emissions. Coal-derived liquid fuels can also be used as hydrogen carriers, which when reformed can produce hydrogen for transportation, fuel cells, and other forms of distributed hydrogen generation.

Although the FT process is commercial in South Africa and Malaysia, several challenges face the production of liquid fuels from coal. The coal-derived synthesis gas contains trace contaminants that poison the catalysts used in the synthesis of liquid fuels. Some catalysts are sensitive to even ppb levels of these contaminants. In addition, the ratio of hydrogen-to-carbon monoxide in the feed may need to be adjusted prior to liquid fuels synthesis. Catalyst separation from the waxes that result from FT synthesis also presents a challenge.

Other challenges facing the conversion of coal to liquid fuels are efficiency, footprint, and lower capital costs. These challenges may be overcome through process intensification, consolidating two or more unit operations into a single integrated module that in some cases produces a synergy between certain unit operations that increase efficiency and lowers capital costs.

Furthermore, in today's environment, a third technology is needed in the production of liquid fuels from coal, namely carbon dioxide capture. Large quantities of carbon dioxide are released when coal is

converted to another energy form. Carbon dioxide emissions prompt concerns over global climate change; therefore it is imperative that any new process should be able to operate on a carbon dioxide constrained environment.

Grant applications must: describe a novel, highly selective process for producing liquid fuels from coal. Concepts which utilize biomass or any feedstock other than coal or petroleum coke/resid are not sought. For processes based on the gasification of coal and the subsequent conversion of synthesis gas to liquid fuels, research work on the coal gasification system is not desired, however, the commercial gasifier, gas cleanup, and other components necessary to provide the required synthesis gas for conversion to liquid fuel must be identified. Grant applications should demonstrate familiarity with current commercial technologies for producing liquid fuels from coal as well as with ongoing R&D in this area.

Grant applications should: include a concept providing for the integration of two or more unit operations to demonstrate process intensification. The objective of process intensification is to achieve higher efficiencies, lower capital costs, and a smaller overall footprint over what can be achieved by utilizing separate components for each required unit operation. This may include novel processes that may be located inside the gasifier as well as those located outside the gasifier. In addition, grant applications should also provide for a sequestration-ready carbon dioxide stream.

It is expected that experimental work will be conducted at laboratory and/or bench-scale to demonstrate the technical feasibility of the novel concepts proposed. In support of the experimental work proposed, a preliminary analysis (with a block flow diagram and energy and mass balances) should be provided to aid in assessing the commercial potential of the concept. All emissions and environmental concerns, including the capture of any carbon dioxide must be addressed. The analysis must also address a conceptual strategy for achieving liquid fuel purity sufficient for existing transport applications with minimal refining. Any byproduct species must be identified, including estimated amounts and mode of disposition.

Questions- contact Robert Kornosky (robert.kornosky@netl.doe.gov)

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19. ADVANCEMENTS IN SOLID OXIDE FUEL CELL BALANCE-OF-PLANT AND TURBINE PERFORMANCE AND SUB-SYSTEMS FOR PERFORMANCE ENHANCEMENTS

The goal of the DOE-sponsored Solid State Energy Conversion Alliance (SECA) is to develop commercially-viable ($400/kW) solid oxide fuel cell (SOFC) power generation systems by the year 2010. SOFC-based systems are attractive alternatives to current technologies in large-scale stationary applications - SECA is ahead of schedule in developing these systems for FutureGen, the world's cleanest coal-based power plant. SOFC systems are very efficient, from 40 to 60 percent (depending on system size) and up to 85 percent in large co-generation applications. In addition, the electrochemical conversion in a SOFC takes place at a lower temperature (650ºC to 850ºC) than combustion-based technologies, resulting in decreased emissions, particularly nitrogen oxides.

The Office of Fossil Energy fuel cell program is focused on delivering systems to FutureGen after successfully reducing system cost. In order to achieve SECA program cost targets, small scale spin-off applications requiring diesel fuel will begin in 2010. The subtopics in this topic seek to develop the diesel fuel processing technology necessary for these spin-off applications, as well as novel power electronics topologies for large-scale stationary applications. **Grant applications are sought to address these areas described below in subtopics a and b.**

Research and development to explore turbine components and sub-systems for performance enhancements is also sought. Low heating values typical of syngas and the injection of diluents (to control combustion temperatures and therefore thermal NO_x formation) have resulted in higher mass flows (~14%) through the turbine hot section of integrated gasification combined cycle (IGCC) turbines than for the same model turbines operated with natural gas. This produces 20-25% higher turbine power compared to natural gas but also tends to increase the heat transfer to the hot section vanes and blades. Where steam is used as a diluent to control NOx, the higher heat transfer properties for steam compared to air also further tends to increase the heat load to hot section components. Accordingly, current IGCC turbines have been operated at reduced firing temperatures to maintain hot gas parts at temperatures similar to those of the same model turbines operated with natural gas. The progression from current syngas to high hydrogen fuels produced from coal syngas and oxy-fuels along with the usual increase in turbine inlet temperature through time to increase performance (power and efficiency) will produce additional heat loads and aerodynamic/cooling requirements for hot section components. **Grant applications are sought to address these areas described below in subtopics c and d.**

a. 1 to 5 kWe Diesel Reformer—Grant applications are sought to: develop and test a new and novel integrated diesel fuel processing solution for SOFC-based auxiliary power units (APUs). APUs for Class 8 diesel trucks and recreational vehicles are strong early market for SOFC systems – by providing on-board power while the vehicle engine is off, SOFC-based APUs address the challenges presented by anti-idling legislation enacted in many states. The choice of fuels for these applications will focus on diesel liquid fuels because of their availability, low cost and existing distribution networks. Diesel must be reformed in order to achieve the desired gas compositions (consisting of hydrogen, carbon monoxide, and moderate levels of methane (< 10 mole %), required for acceptable SOFC electrochemical performance. Therefore, grant applications are sought to design, fabricate, and test low-cost, compact, and reliable integrated diesel fuel reformers for these applications. For any new design, cost, manufacturability, and reliability are critical factors in meeting SECA program goals.

The reformer may be based upon plasma-assisted partial oxidation, catalytic partial oxidation or autothermal reforming (ATR) technologies. Designs must explicitly address and include the diesel injection system, mixing chamber, reactor vessel, and reaction media. Additional design requirements include: (1) operation within the temperature range 600 to 1000 °C; (2) turndown capability maximized - not less than 4 to 1; (3) pressure drops below 1 psi, throughout the device; (4) minimal water usage, consistent with water recovery from the fuel cell anode or other point within the process; (5) maximum carbon suppression; and (6) a volume of less than 10 L. In addition, practical SOFC APU system applications require fast start-up, processed fuel reformate availability to accommodate power demand transients, and the ability to accommodate part-load operation – all with minimal hydrocarbon (preferably methane) slip. Finally, the diesel reformer catalyst itself must be able to handle up to 50 ppmv of sulfur in the fuel without sulfur poisoning and provide stable, long-term operation (> 5,000 hours) before maintenance is required.

Phase I work shall center upon a systems analysis and preliminary reformer design for the intended application. In addition, a detailed cost analysis shall be performed, assuming an annual production volume of 80,000 units. If selected for Phase II, the recipient shall fabricate and test the unit to demonstrate suitability to the intended application.

Questions – contact Dave Berry (david.berry@netl.doe.gov)

b. Evolved Designs for High-Power, Low Cost, High Performance Fuel Cell Power Conditioning Systems—Research is currently underway within the SECA program to develop and demonstrate fuel cell technologies that can support power systems with capacities of 100 megawatts or more in central power stations utilizing gasified coal. These systems much achieve at least 50% overall higher heating value (HHV) efficiency in converting the energy in coal to grid power, capture 90% or more of the systems CO_2 emissions, and be capable of being manufactured at a cost of $400 per kilowatt, exclusive of the coal gasification unit and CO_2 separation subsystems.

Grant applications are sought to: identify new topologies that will reduce capital and life cycle costs, increase efficiency, improve reliability, and improve serviceability of power conditioning systems for future large-scale, central station fuel cell systems capable of providing electricity to the power grid at the transmission circuit level. The boundary conditions for the research are to convert the 300 to 800 V DC output from fuel cell modules to transmission level voltage (300 to 500 kV AC) where the net delivered plant power is 300 MW, and each fuel cell module is a few hundred kW in generation capacity.

Research has demonstrated that simulated evolution can reconfigure, adapt, and design electronic structures in an automated manner. Applications include both analog and digital circuitry design using Genetic algorithms (Gas), which are stochastic parallel search algorithms used to search large, non-linear search spaces where expert knowledge is difficult or lacking.

Power conditioning topologies that may be considered include commercially available step-up transformers, high frequency versus low frequency systems, converters with few stages versus multi-stages, high voltage versus low voltage inverters, and power converters for individual fuel cell modules versus multiple modules. Advanced component technologies that may be considered include advanced semiconductor devices made with the SiC material, advanced nano-crystalline magnetic materials for filters and transformers, as well as advanced cooling system and capacitor technologies. This subtopic seeks novel approaches to apply Genetic algorithms to evolve designs for high-power, low-cost, high-performance fuel cell power conditioning topologies that aggregate multiple fuel cell modules for central power station service. **STTR applications are encouraged for this subtopic.**

Questions – contact Don Collins (donald.collins@netl.doe.gov)

c. Innovative Cooling Approaches—Grant applications are sought for: research and development to explore innovative cooling approaches that allows ceramic and metal turbine parts to survive in working fluids with higher temperatures. Research is needed to explore innovative cooling approaches and/or increased film-cooling effectiveness to improve component durability while also decreasing sensitivity to potential surface roughness effects or propensity to collect deposits in and around cooling hole exits. Experiments to evaluate and demonstrate these approaches and their benefits are desirable. Effects on cooling effectiveness should be at least analytically evaluated for a range of flow path heat transfer properties (e.g., resulting from different water vapor levels) associated with coal syngas, high hydrogen fuels derived from syngas, and oxy-fuels. Candidate cooling approaches to be explored should be first discussed with turbine suppliers to consider their manufacturability. Future power plants using coal gasification, combined cycles or oxy-fuel cycles that are targeting efficiencies greater than

50% and the associated higher firing temperature will require new advanced cooling technologies. By using closed loop steam cooling in place of compressor discharge air, the 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 better use of available compressor air. Systems studies have shown that the current state of the art turbine inlet temperature of around 1427ºC (2600ºF) may need to be raised even higher in order to meet the long term Turbine Program efficiency goals. The challenge is to find new, novel, and more effective cooling solutions for the hottest sections of the turbine including the combustor, reheater, transition section, 1st stage nozzle, stators, rotor blades and disks. Preferably, such new methods should not increase the manufacturing costs significantly. One example of such an innovative active cooling concept is transpiration cooling. Transpiration cooling, made possible in part through platelet technology has allowed very high heat flux rocket engines and missile re-entry nose cones to be deployed. Platelet technology has proven to be highly successful for meeting these challenging high heat flux cooling requirements. This subtopic solicits grant applications for advanced cooling technology (such as, but not limited to platelet technology).

Questions - contact Rondle Harp (rondle.harp@netl.doe.gov)

d. Increasing Performance of Gas Turbine Exhaust Systems—Grant applications are sought for: research and development that mitigate or reduce turbine exhaust (diffuser) pressure losses from the increased volumetric flow. An increase in the power extracted by the turbine can be achieved by an increase of the pressure at the inlet plane of the turbine, or by a decrease of the back pressure at the exit plane of the turbine, or both. Most approaches for improving turbine performance address the first option, for example increasing the pressure ratio of the compressor and therefore the combustor pressure and the combustor temperature. Other approaches seek to improve the high-temperature components: materials, coatings, corrosion resistance, and high-temperature bearings. Raising peak temperatures, however, increase NO_x production, require expensive metallurgy, and reduce service life. This subtopic seeks grant applications to increase the power extraction of a gas turbine by lowering the back pressure at the exit plane of gas turbines, which would allow for reductions in heat rate, peak temperature, and fuel consumption while maintaining rated power, or increase power at constant heat rate, or both, yielding greater operational flexibility. In addition, DOE's research indicates that gas turbines operated with syngas and hydrogen fuels from coal gasification will have a higher volumetric flow than equivalent oil or natural gas-fired turbines.

Questions - contact Rondle Harp (rondle.harp@netl.doe.gov)

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* American Institute of Aeronautics and Astronautics/ Society of Automotive Engineers/American Society of Mechanical Engineers/American Society for Engineering Education

20. HIGH PERFORMANCE MATERIALS FOR LONG TERM FOSSIL ENERGY APPLICATIONS

New materials, ideas, and concepts are required to significantly improve performance and reduce the costs of existing fossil systems or to enable the development of new systems and capabilities. The Fossil Energy Materials Program conducts research and development on high-performance materials for longer-term fossil energy applications, including gas separations and storage. The program is concerned with operation in the hostile conditions created when fossil fuels are converted to energy. These conditions include high temperatures, elevated pressures, and corrosive environments (reducing conditions, gaseous alkali). Grant applications are sought only for the following subtopics:

a. Surface Modification of Alloys for Ultrasupercritical Coal-Fired Boilers—The implementation of ultrasupercritical boilers will require materials with high-temperature creep properties and high-temperature oxidation and corrosion resistance. New ferritic, austenitic, and nickel-based alloys have been designed to meet the creep resistance demands, but the high operating temperature poses the risk of accelerated material degradation in various harsh environments. In a coal-fired boiler, there are oxidizing and corroding environments that range from simple gas attack to the deposition microclimates of complex nature. The gases can be oxidizing, such as mixtures of O_2 and SO_2/SO_3, or a more complex mixture including aggressive gaseous compounds such as H_2S, HCl, COS, CS_2, CO, and methyl mercaptan. These later gaseous compounds are usually generated during the substoichiometric combustion of coals when modified combustion systems are implemented for NO_X emissions control. Similarly, the substoichiometric combustion process generates unburned carbon and pyritic particulate that, based on the hydrodynamics of the fireball, may end up deposited on heat transfer surfaces. The deposits can generate various local reducing environments, ranging from carbonaceous to sulfidizing, and even low-melting eutectics that act as a flux on the metal surface.

Surface modification techniques could provide an alternative to otherwise costly nickel-based materials. The science of thermal spray has evolved in the last 15 years with the implementation of techniques, such as High Velocity OxyFuel (HVOF), that have improved the quality of the applied coatings. Other emerging techniques include cold spray technology, which when combined with nano-size powders can provide flexibility and economic advantages, and weld overlay and chromizing technologies, which are used to ensure that pressure parts are adequately protected from the operating environment. Grant applications are sought to develop new surface modification techniques, or to optimize the techniques mentioned above, for the protection of high temperature alloys used in ultrasupercritical coal-fired boilers.

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

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

In addition, materials need to be developed for joining ceramic and metal parts in newly developed hydrogen gas separation membranes which operate at high temperatures. This high temperature 'glue' will replace materials used at lower temperature. The work should focus on new strategies and materials and evaluating the strength and chemical properties of the latter.

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

c. Computational Tools for Materials Development—Novel materials that can withstand high temperatures and extreme environments, as well as those needed for the separation and storage of hydrogen are dominant themes in materials development for efficient energy systems. For the former, basic requirements are elevated melting temperatures, high oxidation and corrosion resistance, the ability to resist creep, and high toughness, and encompass some of the most challenging problems in materials science. Computer simulation to study the structure, properties, and processing of materials on the atomic scale is needed to speed the advancement of innovative strategies that would replace traditional, trial-and-error experimental methods which are costly and time-consuming. A wide range of computer modeling tools, ranging from highly accurate quantum mechanics (electronic structure) methods to simple interatomic potentials, could be brought to bear on addressing critical materials needs.

In gas separation and storage systems, there is a need to use computer simulations for the development of novel membranes for gas separations, especially hydrogen separation from coal-derived gases. Novel membranes could include: micro-engineered membranes, nano-composite membranes, inorganic membranes, and those needed for membrane reactors. Theory, modeling, and simulation will enable (1) understanding the physics and chemistry of hydrogen interactions at the appropriate size scale and (2) the ability to simulate, predict, and design materials performance for separation and storage.

An effective way to accelerate research in this field is to use advances in materials simulations and high performance computing and communications to guide experiments. This synergy between experiment and advanced materials modeling will significantly enhance the synthesis of novel high-temperature materials. 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. The research should only address materials of interest to fossil energy conversion systems.

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

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21. ENVIRONMENTAL INNOVATIONS FOR FOSSIL ENERGY APPLICATIONS

The use of coal in energy utilization and conversion systems suffers from a number of considerations with respect to the fuel itself. Coal is a solid fuel containing components that are precursors of environmental pollutants or materials that are potentially damaging to downstream components. Further, coal contains mineral matter that is converted into ash, which can lead to suspended particulates in air, erosion of or deposition in downstream components, and problems of solid waste disposal. This topic seeks to mitigate the environmental disadvantages of coal utilization, including its potential impact on water quality and availability, through improvements in various aspects of the coal utilization cycle. The research is expected to provide high-quality scientific information on present and emerging environmental issues for use in regulatory and policy decision-making. Environmental considerations and the concomitant need for low-cost compliance options are the primary drivers of the current research program. Also the development of robust sensor networks for coal power systems, using instrumentation that can withstand the harsh conditions of advanced power generation systems. **Grant applications to address these needs are solicited only in the following subtopics:**

a. Development of Technologies to Reduce Freshwater Use and Consumption in Coal-Fired Power Plants—Electricity production requires a reliable, abundant, and predictable source of freshwater – a resource that is limited in many parts of the United States. The process of thermoelectric generation from fossil fuels is water intensive – an average of 25 gallons of water is needed to produce a kWh of electricity, primarily for steam cooling purposes. In addition, power plants also use water for operation of pollution control devices such as flue gas desulfurization (FGD) technology as well as for ash handling, wastewater treatment, and wash water. Requiring more than 136 billion gallons of freshwater a day (USGS Circular 1268, 2004), the existing fleet of fossil fuel fired power plants is second only to agriculture (irrigation and livestock) in terms of fresh water use in the United States.

In addition to the significant amount of freshwater needed for the generation of electricity, power plants may also impact water quality. Both the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) regulate the discharge of pollutants from power plants to receiving waters as well as the intake of water for cooling and other power plant needs. For instance, the CWA contains Sections 316(a) and 316(b) which cover water thermal discharge and cooling water intake structures.

Grant applications are sought for reducing the amount of freshwater required for coal power plant operations and minimizing the potential impacts of plant operations on water quality. Therefore, grant applications are sought in the following areas of interest: 1) reduction in the quantity of freshwater required for coal-fired power generation, 2) water quality improvements in coal power generation, 3) reduction in the capital and operating costs associated with power plant cooling towers and development

of hybrid wet-dry systems that optimize the advantages of wet and dry cooling towers, and 4) development of novel, low-cost treatment technology to allow the use of non-traditional waters (i.e. mine pool water, coal-bed methane produced water, municipal wastewater) as process water for coal power plants.

Questions - contact Sara Pletcher (sara.pletcher@netl.doe.gov)

b. Novel Technologies for Sequestering Mercury in Flue Gas Desulfurization Solids Under Disposal or Beneficial Use Environments—More than half of the electricity generated in the U.S. is produced by coal-fired facilities. In January of 2004, EPA published another draft regulation that targets both sulfur dioxide and nitrogen oxide emissions from power plants. To comply with this regulation, it is anticipated that more units will be equipped with flue gas desulfurization (FGD) technologies. In fact, FGD production in the U.S. may increase by an order of magnitude to almost 200 million tons, thus exceeding the production of all other coal combustion products. The partitioning of mercury in flue gas desulfurization (FGD) sludge is not completely defined, with Hg oftentimes concentrating in fines, rather than crystalline, portion of the solid gypsum. However, Hg has also been found in the scrubber liquor and in the larger crystalline structure. More effective strategies are needed to concentrate and sequester Hg in FGD solids so that it is not released to the environment either during disposal or through re-use.

Grant applications are sought to develop novel technologies and or products that concentrate and sequester mercury in FGD solids under disposal or beneficial use environments, particularly related to the use of flue gas desulfurization materials (synthetic gypsum) in wallboard production.

Questions – contact Robert Patton (patton@netl.doe.gov)

c. Novel Approaches for Monitoring the Condition of Advanced Power Plants—Novel approaches are sought for the development and design of on-line instrumentation and sensors capable of monitoring the state of critical equipment and components within an advanced power plant. Instrumentation and sensors capable of monitoring in high temperature harsh environments for the measurement of stress/strain, corrosion, thermal barrier coating wear, fouling, and/or material fatigue/cracking are of interest. New approaches to embedded sensor designs or non-destructive evaluation (NDE) techniques are of interest along with wireless data communication capabilities. Development and utilization of other types of measurements are also of interest for the creation of a network of condition monitoring sensors. Sensor networks will likely include the use of harsh environment physical and chemical/gas sensors as well as those that operate at more benign conditions to provide real time diagnostic capabilities. Employing robust sensing networks will enable the development or use of algorithms and models for the prediction of equipment/component maintenance, remaining life and failure. Predictive algorithms and models should be considered an integral part of a robust condition monitoring system.

Grant applications are sought for condition monitoring sensor networks and software will improve system control, protect capital equipment investment, and promote safety through prevention of catastrophic equipment failure. Equipment that could potentially benefit from the development of advanced condition monitoring approaches include coal gasifiers, turbines, advanced coal combustion systems, selective catalytic reduction systems and other critical or high maintenance equipment commonly employed in energy and power generation systems.

Questions – contact Susan Maley (susan.maley@netl.doe.gov)

References:

Subtopic a: Development of Technologies to Reduce Freshwater Use and Consumption in Coal-Fired Power Plants

1. "Water - Energy Interface," U.S. DOE National Energy Technology Laboratory, http://www.netl.doe.gov/technologies/coalpower/ewr/water/ (To see how this program fits into NETL; start at the NETL home page, http://www.netl.doe.gov/. On the left menu select "Technologies". Under "Technologies," select "Coal & Power Systems" then "Environmental & Water. In the center of the page select the third bullet, "Water-Energy Interface". These instructions should bring the viewer to the same Web location, and give a broader perspective of this subtopic.)

2. "Estimated Use of Water in the United States in 2000," United States Geological Service (USGS), May 2004. (USGS Circular 1268) (Full text available at: http://pubs.usgs.gov/circ/2004/circ1268/)

3. "Clean Water Act Snapshot," United States Environmental Protection Agency Website. (URL: http://www.epa.gov/region5/water/cwa.htm)

4. "Safe Drinking Water Act – Regulations and Guidance," United States Environmental Protection Agency Website. (URL: http://www.epa.gov/safewater/regs.html)

Subtopic b: Novel Technologies for Sequestering Mercury in Flue Gas Desulfurization Solids Under Disposal or Beneficial Use Environments

5. Pflughoeft-Hassett, D.F., et al., "Barriers to the Increased Utilization of Coal Combustion/Desulfurization By-Products by Government and Commercial Sectors – Update 1998," Topical Report, Energy & Environment Research Center, University of North Dakota, July 1999. (Available at: http://www.netl.doe.gov/technologies/coalpower/ewr/ref-shelf.html. In the Table of Contents box, click on "Coal Utilization By-Products", then click on the document title at the ninth bullet and wait.)

6. Moretti, C. J., "An Evaluation of Disposal and Utilization Options for Advanced Coal Utilization Wastes," American Power Conference, Chicago, IL, April 9-11, 1996. (Available in PDF at: http://www.netl.doe.gov/technologies/coalpower/cctc/cctdp/bibliography/misc/bibm_cwbu.html. Scroll half way down page and click on title above.)

7. Aljoe, W. W., et al., "The Fate of Mercury in Coal Utilization By-Products - DOE/NETL's Research Program," presented at the China Workshop on Mercury Control from Coal Combustion, Beijing, China, Oct. 31 – Nov. 2, 2005. (Full text available at: http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/). Under "The Coal Utilization By-Products (CUB) program" see second title in blue box.)

Subtopic c: Novel Approaches for Monitoring the Condition of Advanced Power Plants

8. Descriptions of the advanced power systems can be found on the National Energy Technology Laboratory's (NETL) Website: http://www.netl.doe.gov/

22. OIL AND NATURAL GAS TECHNOLOGIES

The DOE seeks innovative methods and concepts that will contribute to more efficient and economic processes for the recovery of oil and natural gas. 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 supports innovative research that supplements and complements, but does not duplicate or displace, private and other public research and development efforts. Grant applications must propose a concept development effort and a work plan which should be supplemented with the development of a project team (including partnership arrangements) to pursue the idea into a workable system. **Grant applications are sought only in the following subtopics:**

a. CO_2 Flooding—To prolong the sustainability of the oil supply over the longer-term and to aid in the sequestration of carbon for the environment, dramatic improvements to carbon dioxide flooding are required. Grant applications are sought to develop: 1) chemicals or methods to improve sweep efficiency; 2) methods to monitor the CO_2 flood front for better reservoir management; and 3) chemicals or methods to inhibit asphaltene dropout during CO_2 flooding. All grant applications must lead to cost-effective ways to improve CO_2 flooding.

Questions – contact James Ammer (James.Ammer@netl.doe.gov)

b. Methane Hydrates—The objective of this subtopic is to receive applications for research projects that will develop new methane hydrate production tools and technologies, and/or provide a better understanding of the role of methane hydrates in the natural environment. Specifically, grant applications are sought to support 1) alternative approaches, or focused studies of new, novel, and cost-effective approaches to producing methane hydrates from natural accumulations, (note: any work on numerical simulation should clearly recognize and incorporate the existing models already in use/development) or 2) research that improves understanding of the risks and implications for methane release from natural hydrate accumulations due to either natural processes or human activities. Applicants may review information about the DOE's National Methane Hydrate R&D Program and current DOE methane hydrate projects at http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/maincontent.htm.

Questions – contact James Ammer (James.Ammer@netl.doe.gov)

References:

Subtopic a: CO_2 Flooding

1. Justice, Jim, et al., "Interwell Seismic for Reservoir Characterization and Monitoring," SPE/DOE Improved Oil Recovery Conference, Tulsa, OK, April 2000. (SPE Paper No. 62588-MS) (Paper

preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

2. Wagener, D. C. and Harpole, K. J., "Determination of Relative Permeability and Trapped Gas Saturation for Predictions of WAG Performance in the South Cowden Unit CO_2 Flood," presented at the 1996 SPE/DOE Tenth Symposium on Improved Oil Recovery, Tulsa OK, April 21-24, 1996. (SPE Paper No. 35429-MS) (Paper preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

3. Tsau, Y. S. and Heller, J. P., "How Can Selective Mobility Reduction of CO_2-Foam Assist in Reservoir Floods?" presented at the 1996 Permian Basin Oil and Recovery Conference, Midland TX, March 27-29, 1996. (SPE Paper No. 35168-MS) (Paper preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

4. Yaghoobi, H. and Heller, J. P., "Effect of Capillary Contact on CO_2-Foam Mobility in Heterogeneous Core Samples," presented at the 1996 Permian Basin Oil and Recovery Conference, Midland Texas, March 27-29, 1996. (SPE Paper No. 35169-MS) (Paper preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

5. Yaghoobi, H. and Heller, J. P., "Improving CO_2 in Heterogeneous Media," presented at the 1996 SPE/DOE Tenth Symposium on Improved Oil Recovery, Tulsa, OK, April 21-24, 1996. (SPE Paper No. 35403-MS) (Paper preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

6. Hallenbeck, L. D., et al., "Design and Implementation of a CO_2 Flood Utilizing Advanced Reservoir Characterization and Horizontal Injection Wells in a Shallow Shelf Carbonate Approaching Waterflood Depletion," pp. 26-27, May 1996. (NTIS Order No. DE96001234) (Abstract and ordering information available from National Technical Information Service (NTIS). Telephone: 1-800-553-6847. Website: http://www.ntis.gov/ (Search by order no. Please note: Items that are unavailable via the Website might be obtained by phoning NTIS.)

7. Michels, M., et al., "Enhanced Water Flooding Design Using Diluted Surfactant Concentrations for North Sea Conditions," presented at the 1996 SPE/DOE Tenth Symposium on Improved Oil Recovery, Tulsa, OK, April 21-24, 1996. (SPE Paper No. 35372-MS) (Paper preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

8. Yin, Y. R, et al., "Asphaltene Inhibitior Evaluation in CO_2 Floods: Laboratory Study and Field Testing," presented at 2000 SPE Permian Basin Oil and Gas Recovery Conference, Midland, TX, March 21-23, 2000. (SPE Paper No. 59706-MS) (Paper preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

9. Leontaritis, K.J. and Mansoori, G. A., "Asphaltene Deposition: A Survey of Field Experiences and Research Approaches," *Journal of Petroleum Science and Engineering*, 1(3): 229-239, August 1988.

(Abstract and ordering information available at: http://sciencedirect.com. In center of page under "Search for a title", search for journal, and use information above to locate article.)

10. Leontaritis, K.J., et al., "A Systematic Approach for the Prevention and Treatment of Formation Damage Caused by Asphaltene Deposition," *Production and Facilities*, 9(3): 157-164, August 1994. (SPE Paper No. 23810-PA) (Paper preview and ordering information available at: http://www.spe.org/elibrary/app/search.do. Search by paper number or title.)

Subtopic b: Methane Hydrates

11. Applicants can review information about the DOE National Methane Hydrate R&D Program and current DOE methane hydrate projects at: http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/maincontent.htm.

12. National Research Council, "Charting the Future of Methane Hydrate Research in the United States," 1st ed., Washington, DC: National Academies Press, 2004. (Full text can be read online at: http://www.nap.edu/catalog/11094.html)

23. CLIMATE CONTROL TECHNOLOGY FOR FOSSIL ENERGY APPLICATIONS

This topic addresses carbon dioxide (CO_2) and other non-CO_2 greenhouse gases, principally methane (CH_4), which are natural and important components of the atmosphere that, together with water vapor, exert a "greenhouse" effect trapping heat within the Earth's atmosphere. This phenomenon has, thus far, maintained the planet's temperate climate. However, because CO_2 is generated by the combustion of all carbon-based fuels, human activity has raised global emissions of CO_2 and other, non-CO_2 greenhouse gases, from a negligible level two centuries ago to significant amounts today.

It has been postulated by some in the scientific community that the current rate of greenhouse gas build-up in the atmosphere worldwide will contribute to global warming because these greenhouse gases, by trapping heat more efficiently with their increased atmospheric concentrations, could put the global climate out of balance and thus cause significant adverse consequences for human health and welfare.

Hence, the capture and permanent sequestration of CO_2, as well as other non-CO_2 greenhouse gases (GHG), has become a major world wide goal. In the United States, the capture and sequestration of CO_2 and other non-CO_2 GHG is expected to be an important element of any strategy to reduce the emission of GHG to the atmosphere. **Grant applications to address these concerns are sought only in the following subtopics:**

a. Breakthrough Performance Improvements on Supporting Systems for Post Combustion CO_2 Capture—Significant research and development is currently being pursued for new technologies to separate and capture CO_2 from flue gas streams produced by existing coal-fired electric generating power plants and forecasted capacity addition. However, some technologies are performance and cost constrained by their dependence on supporting systems, which are critical to their specific process. For example, process integration improvements related to oxy combustion can only achieve incremental

performance efficiencies and cost reductions. Step change improvements are dependant on the cost and performance associated to the production of oxygen.

Grant applications are sought to develop technologies that can substantially lower the cost of supporting systems, such as oxygen production units, when integrated with the dependant CO_2 capture technology. The complete CO_2 capture technology with the innovative supporting system must demonstrate the potential to achieve the Sequestration Program performance and cost targets for flue gas produced by existing coal-fired power plants. The CO_2 capture technology should be capable of 90% or greater reduction in CO_2 emissions per net kWh and result in less than a 20% increase in the cost of energy services. The technology proposed should demonstrate the scale-up potential for application for coal-fired power plants that are 300 MW and higher.

Applications should provide a technical and economic comparative evaluation to current and emerging technologies that articulates how their technology will achieve the respective Sequestration Program cost and performance targets. A systems and economic analysis based on NETL's Carbon Capture and Sequestration Systems Analysis Guidelines (April 2005) and a commercialization roadmap for the proposed technology shall be required during the performance period.

Questions - contact José Figueroa (jose.figueroa@netl.doe.gov)

b. Advanced Monitoring Technologies for Geologic CO_2 Sequestration—Monitoring, mitigation, and verification (MM&V) is defined as the capability to measure the amount of CO_2 stored at a specific sequestration site, monitor the site for leaks or other deterioration of storage integrity over time, and verify that the CO_2 is stored in a way that is permanent. Measurement technologies need to measure CO_2 in the target formation, integrity of the cap rock, and leakage pathways and migration of CO_2 through the overburden between the cap rock and an existing drinking water sources.

Grant applications are sought for technologies that characterize a formation and overlying burden as a suitable sink and identify potential leakage points. Technologies are also sought to monitor the fate of CO_2 within the geologic formation that will be used as potential sinks to identify possible migration of CO_2 through the existing overburden to potential drinking water sources or the surface. Approaches of interest include, but are not limited to advancements in surface-to-borehole seismic, micro-seismic, cross-well electromagnetic, electrical resistance tomography, water chemistry, passive pressure and seismic sensors. In addition, advances in technologies to automate the interpretation of the results from these measurement technologies are sought to speed decision making, conduct multivariate analysis, and/or interpret the response from the technologies that characterize the phase of CO_2 and leakage points.

Questions – contact John Litynski (john.litynski@netl.doe.gov)

References:

Subtopic a: Breakthrough Performance Improvements on Supporting Systems for Post Combustion CO_2 Capture

1. "Carbon Sequestration Technology Roadmap and Program Plan – 2006," U.S. DOE National Energy Technology Laboratory (NETL), May 2005. (Full-text available at: http://www.fe.doe.gov/programs/sequestration/publications/. Click on title that islocated under "Program Plans".)

2. "Carbon Capture and Sequestration Systems Analysis Guidelines – 2005," U.S. DOE National Energy Technology Laboratory (NETL), April 2005. (Full-text available at: http://www.netl.doe.gov/technologies/carbon_seq/Resources/Analysis/pubs/CO2CaptureGuidelines.pdf)

3. "Oxy Combustion Processes for CO_2 Capture from Power Plant," IEA Greenhouse Gas R&D Program, July 2005. (Report Number 2005/9) (Available by request. See: http://www.ccsd.biz/publications/ieacleancoal.cfm?PubID=675)

4. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004," U.S. Environmental Protection Agency, April 15, 2006. (Full text available at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html)

Subtopic b: Advanced Monitoring Technologies for Geologic CO_2 Sequestration

5. "Carbon Capture and Sequestration Systems Analysis Guidelines – 2005," U.S. DOE National Energy Technology Laboratory (NETL), April 2005. (Full-text available at: http://www.netl.doe.gov/technologies/carbon_seq/Resources/Analysis/pubs/CO2CaptureGuidelines.pdf)

6. Vine, E. and Sathaye, J., "The Monitoring, Evaluation, Reporting, and Verification of Climate Change Mitigation Projects: Discussion of Issues and Methodologies and Review of Existing Protocols and Guidelines," prepared for U.S. EnvironmentalProtection Agency, Berkeley, CA: Lawrence Berkeley National Laboratory, December 1997. (Full text available at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsReferenceMERVCReportMethods.html)

PROGRAM AREA OVERVIEW
NUCLEAR ENERGY

Continued use of nuclear power is an important part of the Department's strategy to provide for the Nation's energy security, as well as to be responsible stewards of the environment. Nuclear energy currently provides over 20 percent of the U.S. electricity generation and will continue to provide a significant portion of U.S. electrical energy production for many years to come. Also, nuclear power in the U.S. makes a significant contribution to lowering the emission of gases associated with global climate change and air pollution. New nuclear plants will be needed to meet increasing electricity demand without greenhouse gas emissions, and to provide high temperature process heat for hydrogen production.

The Office of Nuclear Energy (NE) enables the Department of Energy to provide the technical leadership necessary to address critical domestic and international nuclear issues by administering research and development and technical assistance in the following general areas: (1) the Generation IV Nuclear Energy Systems Initiative seeks to develop and demonstrate one or more Generation IV nuclear energy systems that offer advantages in the areas of economics, safety and reliability, sustainability, and could be deployed commercially by 2030; (2) the University Nuclear Energy Research Initiative (NERI) Program addresses key issues affecting the future of nuclear energy in order to preserve U.S. nuclear science and technology leadership; (3) the Nuclear Power 2010 (NP2010) Program conducts research to assure the continued safe and reliable operations of over 100 of the Nation's nuclear power plants, and for the construction of new plants; (4) the University Reactor Fuel and Educational Assistance Program is designed to help retain the U.S. nuclear engineering capability for conducting nuclear research, addressing pressing nuclear environmental challenges, and preserving the nuclear energy option; (5) the Isotope Production Program produces and sells hundreds of stable and radioactive isotopes that are widely used by domestic and international customers for medicine, industry and research applications; and (6) the Global Nuclear Energy Partnership's (GNEP)Advanced Fuel Cycle Initiative (AFCI) supports the growth of nuclear energy by developing and demonstrating technologies that enable transition to a stable, long-term, environmentally, economically and politically acceptable advanced fuel cycle, that will also reduce nuclear proliferation.

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

24. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Nuclear power provides over 20 percent of the U.S. electricity supply without emitting harmful air pollutants, including those that may cause adverse global climate changes. New methods and technologies are needed to address key issues that affect the future deployment of nuclear energy and to preserve the U.S. leadership in nuclear technology and engineering, while enhancing nuclear proliferation resistance. This topic addresses several of these key technology areas: improvements in nuclear reactor technology for existing reactors and evolutionary designs, advanced instrumentation and control (I&C) for very high temperature reactor applications, advanced I&C for use in high radiation environments for Generation IV reactor designs, and advanced techniques for spent-reactor-fuel separations technology and devices.

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]. Grant applications are sought: (1) to improve and optimize the nuclear power plant and its systems, along with component instrumentation and control, by developing and improving the reliability of advanced instrumentation, thermocouples, sensors, controls, and by increasing the accuracy of measuring of key reactor and plant parameters; (2) to improve monitoring of plant equipment performance and aging, using improved diagnostic techniques for in-service and non-destructive examinations; (3) for advanced instrumentation, sensors, and controls for very high

temperature Generation IV reactor designs that can withstand temperatures in excess of 1000° C; (4) for advanced instrumentation, sensors, and controls for very high irradiation environments that will be encountered in advanced evolutionary and Generation IV reactor designs; and (5) to develop light-water-reactor, spent-reactor-fuel separations technology and devices that are compatible with the UREX+ process [see reference 6] and allow for fission product separation of highly radioactive, low-atomic-mass isotopes from spent transuranic and minor actinide wastes (e.g. Pu, Np, Am, Cm, etc) without explicit plutonium separation in order to enhance proliferation resistance, as required for the GNEP and AFCI programs [Ref. 6, 7].

Grant applications that address the following areas of investigation are **NOT** of interest and will be declined: concepts for complete or partial reactor plant designs; generalized thermal-hydraulics analysis (e.g. CFD or two-fluid codes) and probabilistic risk assessment tools or methods; nuclear power plant security, or building/containment enhancements; and NRC safety experiments, testing, licensing, and site permit issues.

In addition, 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 16. Furthermore, grant applications that involve advanced reactor/core computer simulation methods including: (a) reactor/core computer simulation methods for existing light water reactor designs, and (b) advanced reactor design model code development; coupled/parallel thermal-hydraulic-reactor physics tools; safety and performance evaluation methods; ***ab initio*** nuclear cross section/data methods and engineering calculations for ***new*** Generation IV reactor designs, reactors, major reactor components, and reactor core and fuel assemblies should be submitted under Topic 16 directly.

Questions – contact Madeline Feltus, (Madeline.Feltus@nuclear.energy.gov)

References:

1. What's News, U.S. DOE Office of Nuclear Energy, home page, http://www.nuclear.gov

2. Generation IV Nuclear Energy Systems, Office of Nuclear Energy, http://gen-iv.ne.doe.gov/

3. Nuclear Energy Research Initiative (NERI), Office of Nuclear Energy, Science and Technology, http://neri.ne.doe.gov

4. Nuclear Energy Plant Optimization (NEPO), Office of Nuclear Energy, Science and Technology, http://nepo.ne.doe.gov/

5. Miller, D. W., et al., "U. S. Department of Energy Instrumentation, Controls and Human-Machine Interface (IC & HMI) Technology Workshop," Gaithersburg, MD, May 15-17, 2002, IC&HMI Report, September 2002. (Full text, including Recommendations, available at: http://www.science.doe.gov/sbir/NE1_ICHMI_Report.pdf)

6. Advanced Fuel Cycle Initiative (AFCI) Annual Report 2003, (Available at: http://nuclear.gov/reports/AFCIAnnualRpt03.pdf

7. Global Nuclear Energy Partnership (GNEP), U. S. Department of Energy, http://www.gnep.energy.gov/

PROGRAM AREA OVERVIEW
NUCLEAR PHYSICS

Nuclear physics research seeks to understand the structure and interactions of atomic nuclei and the fundamental forces and particles of nature as manifested in nuclear matter. Nuclear processes are responsible for the nature and abundance of all matter, which in turn determines the essential physical characteristics of the universe. The primary mission of the Nuclear Physics (NP) program is to develop and support the scientists, techniques, and facilities that are needed for basic nuclear physics research. Attendant upon this core mission are responsibilities to enlarge and diversify the nation's pool of technically trained talent and to facilitate transfer of technology and knowledge to support the nation's economic base.

Nuclear physics research is carried out at National accelerator facilities and through university programs. The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) allows detailed studies of how quarks and gluons bind together to make protons and neutrons. In an upgrade currently being developed, the CEBAF electron beam energy will be doubled from 6 to 12 GeV. The Relativistic Heavy Ion Collider (RHIC), in operation at Brookhaven National Laboratory (BNL), is forming new states of matter that have not existed since the first moments after the birth of the Universe. A beam luminosity upgrade is proposed for the future; a new electron-ion collider is also being discussed. The NP program also supports research and facility operations that are directed towards understanding the properties of nuclei at their limits of stability and of the fundamental properties of nucleons and neutrinos. This research is made possible with the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL), and the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory (ORNL), which provide complementary facilities for stable and radioactive beams as well as a variety of species and energies. A local program of basic and applied research is supported at the 88-Inch Cyclotron of the Lawrence Berkeley National Laboratory (LBNL). In addition, the operations of accelerators for in-house research programs at four universities (Yale University, University of Washington, Texas A&M University, and the Triangle Universities Nuclear Laboratory (TUNL) at Duke University) provide unique instrumentation with a special emphasis on the training of students.

The nuclear physics program also supports non-accelerator experiments such as the Sudbury Neutrino Observatory (SNO) facility, constructed by a collaboration of Canadian, English, and U.S. supported scientists; this facility is now taking data on solar neutrino fluxes and providing the first results on the "appearance" of oscillations of electron neutrinos into another neutrino type. A rare isotope beam facility is being considered which would provide a way to explore the limits of nuclear existence, is being considered. By producing and studying highly unstable nuclei that are now formed only in the stars, scientists could better understand stellar evolution and the origin of the elements.

Our ability to continue making a scientific impact on the general community relies heavily on the availability of cutting edge technology and advances in detector instrumentation, electronics, software, and accelerator design. The technical topics that follow describe research and development

opportunities in the equipment, techniques, and facilities that are needed to conduct and advance nuclear physics research at existing and future facilities.

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

25. NUCLEAR PHYSICS ELECTRONICS DESIGN AND FABRICATION

The DOE seeks developments in detector instrumentation electronics with improved energy, position, timing resolution, sensitivity, rate capability, stability, dynamic range, durability, pulse-shape discrimination capability, and background suppression. Of particular interest are innovative readout electronics for use with the nuclear physics detectors described in Topic 26. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Advances in Digital Electronics—Digital signal processing electronics are needed to replace analog signal processing in nuclear physics applications. Grant applications are sought to develop: (1) digital pulse processors that simplify or replace analog designs and have sufficient flexibility to incorporate such features as pile-up rejection and ballistic deficit correction; (2) digital pulse-processing electronics, including pulse-shape discrimination, for commonly used nuclear physics detectors in general, and for position-sensitive solid-state detectors or highly segmented CdZnTe detectors in particular; and (3) fast digital processing electronics that improve the accuracy of the analog electronics, such as in determining the position of interaction points (of particles or photons) to an accuracy smaller than the size of the detector segments.

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

b. Circuits—Grant applications are sought to develop custom-designed integrated circuits, as well as circuits (including firmware) and systems, for rapidly processing data from highly segmented, position-sensitive germanium detectors (pixel sizes of approximately 1 cm^2) and from particle detectors (e.g., gas detectors, scintillation counters, silicon drift chambers, silicon strip detectors, particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Areas of specific interest include: (1) representative circuits such as low noise preamplifiers, amplifiers, peak sensors, analog storage devices, analog-to-digital and time-to-digital converters, transient digitizers, and time-to-amplitude converters; (2) multiple-sampling application-specific integrated circuits (ASICs), to allow for pulse-shape analysis; (3) readout electronics for solid-state pixilated detectors, including interconnection technologies and amplifier/sample-and-hold integrated circuits; and (4) constant-fraction discriminators with uniform response for low and high energy gamma rays. These circuits should be fast; low-cost; high-density; configurable in software for thresholds, gains, etc.; easy to use with commercial auxiliary electronics; low power; compact; and efficiently packaged for multi-channel devices.

In addition, planned luminosity upgrades at RHIC will require fine-grained vertex and tracking detectors (both silicon and gas) for high particle multiplicity environments. Therefore, grant applications are sought for advances in microelectronics that are specifically designed for low-noise amplification and processing of detector signals, and that are suitable for these next generation detectors. The microelectronics and associated interconnections must be lightweight and have low power dissipation.

Of particular interest are designs that minimize higher-gate leakage currents due to tunneling and maintain dynamic range.

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

c. Advanced Devices and Systems—Active Pixel Sensors in CMOS (complementary metal-oxide semiconductor) technology are replacing Charge Coupled Devices as imaging devices and cameras for visible light. Several laboratories are exploring the possibility of using such devices as direct conversion particle detectors. The charge produced by an ionizing particle in the epitaxial layer is collected by diffusion on a sensing electrode in each pixel. The charge is amplified by a relatively-simple low-noise circuit in each pixel and read out in a matrix arrangement. If successful, this approach would make possible high-resolution, position-sensitive particle detectors with very low mass (approximately 50 microns of silicon in a single layer). This approach would be superior to the present technology that uses a separate silicon detector layer, which is bump-bonded to a CMOS readout circuit. Grant applications are sought to advance the development of integrated detector-electronics technology, using CMOS monolithic circuits as particle detectors. The new active pixel detector with its integrated electronic readout should be based on a standard CMOS process. The challenge is to design a sensor with low noise readout circuits that have sufficiently high sensitivity and low power dissipation, in order to detect a minimum ionizing particle in a thin "epitaxial-like" or equivalent layer (~10-30 microns).

Grant applications also are sought for the next generation of active pixel, or even strip, sensors which use the bulk silicon substrate as the active volume. This more advanced approach would have the advantage of developing relatively larger signals and allowing sensitivity to non-minimum ionizing particles such as MeV-range gamma rays.

Lastly, grant applications are sought for improved or advanced devices and systems used in conjunction with the electronic circuits and systems described in subtopics a and b. Areas of interest regarding these devices include radiation-hardened, wide-bandgap semiconductors (i.e., semiconductor materials with bandgaps greater than 2.0 electron volts, including Silicon Carbide (SiC), Gallium Nitride (GaN), and any III-Nitride alloys), inhomogeneous semiconductors such as SiGe; and device processes such as silicon-on-insulator (SOI) or silicon-on-sapphire (SOS). Areas of interest regarding systems include bus systems, data links, event handlers, multiple processors, trigger logics, and fast buffered time and analog digitizers. For detectors that generate extremely high data volumes (e.g., >500 GB/s), advanced high-bandwidth data links are of interest. Also of interest are generalized software and hardware packages, with improved graphic and visualization capabilities, for the acquisition and analysis of nuclear physics research data.

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

d. Manufacturing and Advanced Interconnection Techniques—Grant applications are sought to develop: (1) manufacturing techniques for large, thin, multiple-layer printed circuit boards (PCBs) with plated-through holes, dimensions from 2m x 2m to 5m x 5m, with thickness from 100 to 200 microns (these PCBs would have use in cathode pad chambers, cathode strip chambers, time projection chamber cathode boards, etc); (2) techniques to add plated-through holes in a reliable, robust way to large rolls of metallized mylar or kapton (this would have applications in detectors such as time expansion chambers

or large cathode strip chambers); and (3) miniaturization techniques for connectors and cables with 5 times to 10 times the density of standard interdensity connectors.

In addition, many next-generation detectors will have highly segmented electrode geometries with 5-5000 channels per square centimeter, covering areas up to several square meters. Conventional packaging and assembly technology cannot be used at these high densities. Grant applications are sought to develop: (1) advanced microchip module interconnect technologies that address the issues of high density, area-array connections including modularity, reliability, repair/rework, and electrical parasites; (2) technology for aggregating and transporting the signals (analog and digital) generated by the front-end electronics, and for distributing and conditioning power and common signals (clock, reset, etc.); (3) low-cost methods for efficient cooling of on-detector electronics; (4) low-cost and low-mass methods for grounding and shielding; and (5) standards for interconnecting ASICs (which may have been developed by diverse groups in different organizations) into a single system for a given experiment – these standards should address the combination of different technologies, which utilize different voltage levels and signal types, with the goal of reusing the developed circuits in future experiments.

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

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26. NUCLEAR PHYSICS PARTICLE AND RADIATION DETECTION SYSTEMS, INSTRUMENTATION AND TECHNIQUES

The Office of Nuclear Physics is interested in supporting projects that may lead to advances in detection systems, instrumentation, and techniques for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art and outside the usual scope of research and development activities at the nuclear physics national laboratories and university programs. In addition, a new suite of next-generation detectors will be needed for future rare isotope beam capabilities, the 12 GeV energy upgrade at TJNAF, the proposed underground laboratory, the proposed luminosity upgrade at RHIC, and a possible future electron-ion accelerator. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Advances in Detector and Spectrometer Technology—Nuclear physics research has a need for devices to detect, analyze, and track charged particles, and neutral particles such as neutrons, neutrinos, photons, and single atoms. These devices include: solid-state devices such as highly segmented coaxial and planar germanium detectors, and silicon strip, pixel, and silicon drift detectors; photosensitive devices such as avalanche photodiodes, hybrid photomultiplier devices, single and multiple anode photomultiplier tubes, high-intensity (~10^{20} γ/s) gamma-ray current-readout detectors (e.g. Compton Diodes), photodiodes for operation at liquid helium temperatures with a signal-to-noise ratio comparable to a photomultiplier tube, photomultiplier tubes designed to work in a liquid helium environment, and other novel photon detectors; detectors utilizing photocathodes for Cherenkov and UV light detection,

and the development of new types of large area photo-emissive materials such as solid, liquid, or gas photocathodes; micro-channel plates; gas-filled detectors such as proportional, drift, streamer, microstrip, Gas Electron Multipliers (GEMs), Micromegas and other types of micropattern detectors, straw drift tube detectors, time projection chambers, resistive plate chambers, and Cherenkov detectors; liquid argon and xenon ionization chambers and other cryogenic detectors; single-atom detectors using laser techniques and electromagnetic traps; particle polarization detectors; electromagnetic and hadronic calorimeters, including high energy neutron detectors; and detection systems for detecting the magnetization of polarized nuclei in a magnetic field (e.g., Superconducting Quantum Interference Device (SQUIDS) or cells with paramagnetic atoms that employ large pickup loops to surround the sample). Grant applications are sought to develop advancements in the technology of the above mentioned detectors.

With respect to solid state tracking devices, such as the segmented germanium detectors and the silicon drift, strip, and pixel detectors, grant applications are sought for: (1) manufacturing techniques, including interconnection technologies for high granularity, high resolution, light-weight, and radiation-hard solid state devices; (2) highly arrayed solid state detectors for neutron detection, with integrated electronics to read-out pulse height; (3) thicker (more than 1.5 mm) segmented silicon charged-particle and x-ray detectors and associated high density, high resolution electronics; and (4) cost-effective production of n-type and p-type silicon drift chambers with active areas greater than 16 cm^2.

With respect to position-sensitive charged particle and photon tracking devices, grant applications are sought for the development of: (1) position-sensitive, high-resolution germanium detectors capable of determining the position (to within a few millimeters utilizing pulse shape analysis) and energy of individual interactions of gamma-rays (with energies up to several MeV), hence allowing for the reconstruction of the energy and path of individual gamma-rays using tracking techniques; (2) hardware and software needed for digital signal processing and gamma-ray tracking – of particular interest is the development of efficient and fast algorithms for signal decomposition and improved tracking programs; (3) alternative materials, with comparable resolution to germanium, but with significantly higher efficiency and relatively higher temperature operation (in order to overcome the costly and bulky requirement to cool germanium detectors to liquid nitrogen temperatures); (4) improvements and new developments in micropattern detectors – this would specifically include commercial and cost effective production of GEM foils and other types of micropattern structures, such as fine meshes used in Micromegas, as well as novel approaches that could provide high-resolution multidimensional readout; (5) advances in more conventional charged-particle tracking detector systems, such as drift chambers, pad chambers, time expansion chambers, and time projection chambers (areas of interest include improved gases or gas additives that resist aging, improve detector resolution, decrease flammability, and offer larger/more uniform drift velocity); (6) high-resolution, gas-filled, time-projection chambers employing CCD cameras to perform an optical readout; (7) gamma-ray detectors capable of making accurate measurements of high intensities ($>10^{11}$ /s) with a precision of 1-2 %, as well as economical gamma-ray beam-profile monitors; (8) for rare isotope beams, next-generation, high-spatial-resolution focal plane detectors for magnetic spectrographs and recoil separators, for use with heavy ions in the energy range from less than 1 MeV/u to over 100 MeV/u; (9) a bolometer with high-Z material (e.g. W, Ta, Pb) for gamma ray detection with segmentation, capable of handling 100 -1000 gamma rays per second; (10) detectors made of more conventional materials (silicon or scintillator), capable of reconstructing multiple-Compton gamma-ray scattering with mm resolution; and (11) advances in CCD technology, particularly in areas of fast parallel, low-power readout, and cross-talk control.

With respect to particle identification detectors, grant applications are sought for the development of: (1) inexpensive, large-area, high-quality Cherenkov materials; (2) inexpensive, position sensitive, large-sized photon detection devices for Cherenkov counters; (3) high resolution time-of-flight detectors; (4) affordable methods for the production of large volumes of xenon and krypton gas (which would contribute to the development of transition radiation detectors and would also have many applications in X-ray detectors); and (5) very high resolution particle detectors or bolometers (including the required thermistors) based on semiconductor materials and cryogenic techniques. Of particular interest are detector technologies capable of measuring energies of alpha particles and protons with less than 5 keV resolution, thereby allowing spectroscopy experiments using light charged particles to be performed in the same way as spectroscopy experiments using gammas.

Grant applications are also invited for development of systems for predicting insipient failure of detector components through the monitoring/cataloging/scanning of real-time or logged signals.

Grant applications are also invited for innovative design of high-resolution particle separators needed for the spectrometer research program associated with a proposed next generation rare isotope beam facility [15]. (Please contact Dr. J.A.Nolen, Jr. [nolen@anl.gov] of Argonne National Laboratory for additional details).

b. Technology for Rare Particle Detection—Grant applications are sought for particle detectors and techniques that are capable of measuring very weak, rare event signals in the presence of significant backgrounds. Such detector technologies and analysis techniques are required in searches for rare events (such as double beta decay) and for applications in extending our knowledge of new nuclear isotopes produced at radioactive beam facilities. Rare decay and rare phenomenon detectors require large quantities of very clean materials, such as clean shielding materials and clean target materials. For example, neutrino detectors need very large quantities of ultra-clean water.

Grant applications are sought to develop: (1) ultra-low background techniques of contacting, supporting, cooling, cabling, and connecting high-density arrays of detectors – ultrapure materials must be used in order to keep the generated background rates as low as possible (goal is 1 micro-Becquerel per kg); (2) advanced detector cooling techniques and associated infrastructure (high-density signal cabling, signal and high voltage interconnects, vacuum feedthroughs, front-end amplifier FET assemblies) to assure ultra-low levels of radioactive contaminants; and (3) measurement methods for the contaminant level of the ultra-clean materials.

Grant applications also are sought for new technologies to produce large quantities of separated isotopes, such as kg quantities of Ge-76, Se-82, Te-130, and other materials, which are needed for rare particle and rare decay searches in nuclear physics research.

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

c. Large Band Gap Semiconductors, New Bright Scintillators, Calorimeters, and Optical Elements—Grant applications are sought to develop new materials or advancements for photon detection. Of specific interest are: (1) large band gap semiconductors such as CdZnTe, HgI_2, AlSb, etc.; (2) bright, fast scintillator materials ($LaHA_3$:Ce, where HA=Halide) and scintillators with pulse-shape

discrimination (PSD) (n/gamma and charged particle); (3) selenium based detectors (perhaps using GaSe, CdSe or ZnSe); (4) plastic scintillators, fibers, and wavelength shifters; (5) cryogenic scintillation detectors (LXe); (6) Cherenkov radiator materials with indices of refraction up to 1.10 or greater, and with good optical transparency; and (7) new and innovative calorimeter concepts, including new materials, higher packing densities, or innovative fiber and absorber packing schemes.

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

d. Nuclear Targets and High-Radiation Environment Beam Transport Components—Grant applications are sought to develop specialized targets for the nuclear physics program, including: (1) polarized (with nuclear spins aligned) high-density gas or solid targets; (2) frozen-spin active (scintillating) targets; (3) windowless gas targets and supersonic jet targets for use with very low energy charged particle beams; (4) liquid, gaseous, and solid targets capable of high power dissipation when high intensity, low-emittance charged-particle beams are used; (5) high-power targets with fast release capabilities for the production of rare isotopes; and (6) thin (<few micro-g/cm^2), condensed-phase hydrogen targets that can be well localized (1mm in all directions).

Grant applications also are sought to develop the technologies and sub-systems for the targets required at high-power, advanced, exotic beam facilities that use heavy ion drivers for rare isotope production. These targets include those that would be used for heavy ion fragmentation, as well as those that would be used with high power light ion beams for the production of exotic isotopes by spallation reactions.

In addition, grant applications are sought to develop techniques for: (1) the production of ultra-thin films needed for targets, strippers, and detector windows – regarding a next generation rare isotope beam facility, there is a need for stripper foils or films (in the thickness range from a few micrograms per cm^2 to over 10 milligrams per cm^2) for use in the driver linac with very high power densities from uranium beams; and (2) the preparation of targets of radioisotopes, with half-lives in the hours range, to be used off-line in both neutron-induced and charged-particle-induced experiments.

Finally, grant applications are sought for techniques and strategies needed for ion beam transport in the high-radiation environment anticipated at a future exotic beam accelerator facility [19]. Approaches of interest include: (1) simulations to characterize radiation doses to magnets and other components near the production targets and beam dumps; (2) development of appropriate containment for activated coolants such as liquid lithium and water; and (3) development of magnet design concepts that are consistent with the radiation dose, field, and aperture requirements set by optics calculations.

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

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27. 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 and 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 accelerated beams of radioactive isotopes related to the construction of an exotic beam accelerator facility. A major focus in all above cases is superconducting radio frequency (RF) acceleration and its related technologies. Relevance of applications to nuclear physics must be explicitly described. Grant applications that propose using the resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics**:

a. Materials and Components for Radio Frequency Devices—Grant applications are sought to improve or advance superconducting and room-temperature materials or components for RF devices used in particle accelerators. Areas of interest include: (1) peripheral components, for both room temperature and superconducting structures, such as ultra high vacuum seals, terminations, cryogenic radio frequency windows, 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) methods for manufacturing superconducting radio-frequency (>500 MHz) accelerating structures with $Q_0>10^{10}$ at 2.0 K or correspondingly high Q's at higher temperatures such as 4.5 K; (5) improved superconducting materials that have lower RF losses, operate at higher temperatures, and/or have higher RF critical fields than sheet niobium; (6) innovative designs for hermetically sealed helium refrigerators and other cryogenic equipment that simplify procedures and reduce costs associated with repair and modification; (7) development of 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 Kelvin; and (8) development of techniques to create a layer of niobium on the interior of a copper elliptical cavity, such as by energetic ion deposition, so that the resulting 700-1500 MHz structures have $Q_0>8 \times 10^9$ at 2 K and so that overall fabrication costs are reduced relative to using sheet niobium.

Grant applications are also sought for the design, computer-modeling, and hardware development of 5 kW and 13 kW continuous wave (cw) power sources at 350 and 1497 MHz and 1 MW cw RF power sources at 704 MHz. Examples of candidate technologies include (but are not limited to): solid-state devices, multi-cavity klystrons, Inductive-Output Tubes (IOT's), or hybrids of those technologies. For 1497 MHz, the devices should: (1) be capable of operating efficiently over a range of output power levels; (2) include a method for power adjustment other than using the RF drive signal and the voltage of any primary dc source – for example, a klystron should include a gun-current modulating electrode; and (3) have an ac-to-RF conversion efficiency greater than 50%. Computer software for the design or modeling of any of these devices also is sought. Such software should be able to faithfully model the complex shapes fully self-consistently. In addition, software that integrates multiple effects, such as electromagnetic and wall heating, also is desired. Interested parties should contact Dr. Leigh Harwood at Jefferson Laboratory (harwood@jlab.org) or Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (ilan@bnml.gov) for further specifications.

Lastly, grant applications are sought to develop technology that would provide more cost effective, kW-level liquid helium refrigerators. Such technology is needed because the cost effectiveness of a superconducting RF accelerator, typically operating at a temperature of 2 K or below, scales strongly with the cost of liquid helium.

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

b. Design and Operation of Radio Frequency Beam Acceleration Systems—Grant applications are sought for the design, fabrication, and operation of radio frequency accelerating structures and systems for electrons, protons, 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 0.01 times the velocity of light, and with charge-to-mass ratios between 1/6 and 1/240; (2) superconducting RF accelerating structures appropriate for exotic 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) single-cell, 2.856 GHz,

superconducting accelerating structures with high accelerating electric field gradients of 30 MV/m, and with good higher order modes (HOM) extraction and absorption for use in S-band electron storage ring; (6) 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; (7) methods and/or devices for reducing the emittance of relativistic ion beams – such as electron or optical-stochastic cooling; and (8) development of tunable superconducting RF cavities for acceleration and/or storage of relativistic heavy ions.

Grant applications also are sought to develop and demonstrate low level RF system control algorithms or control hardware that provide a robust and adaptive environment suitable for any RF system. Of special interest are approaches that address the particular challenges of superconducting RF systems, but room temperature systems are of interest as well.

Finally, software for the design and modeling of the above systems also is sought. Desired modeling capabilities include: charged particle dynamics in complex shapes including energy recovery analysis; the incorporation of complex fine structures, such as HOM dampers; the computation of particle- and field-induced heat loads on walls; the incorporation of experimentally measured 3-D charge and bunch distributions; and the simulation of the electron cloud effect and its suppression. Contact: Ilan Ben-Zvi (ilan@bnl.gov)

c. Particle Beam Sources and Techniques—Grant applications are sought to develop: (1) particle beam ion sources with improved intensity, emittance, and range of species (areas of interest include high-charge-state sources for heavy ions, sources for negative and light ions, and polarized sources for hydrogen ions and electrons); (2) ion sources for radioactive beams (emphasizing aspects such as high efficiency, high-charge-state ions, small emittance and energy spread, high temperature operation for coupling to high temperature production targets, and element selectivity – e.g., through the use of laser ionization); (3) techniques for secondary radioactive beam collection, charge equilibration, and cooling; (4) technology for stopping energetic radioactive ions in helium gas and extracting them efficiently as high-quality low-energy ion beams; (5) methods and devices to increase the charge state of ion beams (e.g., by the use of special electron-cyclotron-resonance ionizers or special stripping techniques); (6) polarized hydrogen and deuterium (H-/D-) sources with polarization above 90%; (7) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients; (8) ~1 GHz cw polarized electron sources delivering beams of ~10 mA, with longitudinal polarization of ~80%; (9) ~28 MHz cw polarized sources delivering beams of ~500 mA with ~80% polarization; (10) devices, systems, and sub-systems for producing high current (>200μA), variable-helicity beams of electrons with polarizations >80%, and which have very small helicity-correlated changes in beam intensity, position, angle, and emittance; (11) methods to improve high voltage stand-off and reduce field emission from high voltage electrodes in the presence of work-function-lowering material (i.e., cesium), and which are compatible with ultra-high-vacuum environments; (12) 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; and (14) a high-average-power (~100 W), green laser light source, with a RF-pulse repetition rate in the range of 0.5 to 3 GHz for synchronous photoinjection of GaAs photoemission guns.

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 exotic beam accelerator facilities. Special designs that are applicable to use in high radiation areas also are sought.

Grant applications are sought to develop technology for electron rings of future electron-ion colliders, which will operate with very high synchrotron radiation power. These rings should be flexible to accommodate a large range of energy adjustment and electron beam spin manipulation. Of particular interest is the development of radiation adjustable dipole magnets, which will allow large energy changes while maintaining high synchrotron radiation power for strong synchrotron radiation damping and short self-polarization duration. Interested parties should contact Dr. Fuhua Wang (fwang@mit.edu) for further information.

Grant applications are also sought to develop new methods of intense beam acceleration, including technology for proton and electron acceleration in the energy range of several GeV, using non-scaling fixed-field alternating gradient accelerators (FFAG). Areas of interest include: (1) development of rapidly tunable RF systems, (2) demonstration of appropriate magnetic field configurations, and (3) design of an electron model/prototype to directly simulate operation under space-charge-limiting conditions. The nuclear physics interest is the acceleration of charged particles in re-circulating devices. Other potential applications include high-intensity proton drivers for neutron production, waste transmutation, energy production in nuclear reactors, medical proton therapy (250 MeV), and radioisotope production. The acceleration of electrons also could have application to the production of high-intensity synchrotron radiation. Interested parties should contact Dr. Dejan Trbojevic (trbojevic@bnl.gov) for further information.

Grant applications also are sought for: (1) advanced software and hardware to facilitate the manipulation and optimized control of spin polarized beams; (2) advanced beam diagnostic concepts, including new beam polarimeters and fast reversal of stored, polarized beams; (3) novel concepts for producing polarizing particles of interest to nuclear physics research, including electrons, positrons, protons, deuterons, and ^{3}He; (4) development of sophisticated computer software for tracking spin polarized particles in storage rings and colliders; and (5) the design and construction of novel magnet systems for spin polarized beams, including wigglers, Siberian snakes, and superbenders.

Lastly, grant applications are sought to develop software that adds significantly to the state-of-the-art in the simulation of beam physics, including intra-beam scattering, spin dynamics, polarized beam generation, electron cooling, beam dynamics, transport and instabilities, and electron or plasma discharge in vacuum under the influence of charged beams. The software should use modern best practices for software design, should run on multiple platforms, and should run in both serial and parallel configurations. Graphical user interfaces for problem definition and setup also are sought. Contact Ilan Ben-Zvi (ilan@bnl.gov).

d. Accelerator Control and Diagnostics—Grant applications are sought for: (1) "intelligent" software and hardware to facilitate the improved control and optimization of charged particle accelerators and associated components for nuclear physics research (developments that offer generic solutions to problems with respect to the initial choice of operation parameters and the optimization of selected beam parameters with automatic tuning are especially encouraged); (2) advanced beam diagnostics concepts and devices that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum profile, time of arrival, and energy

(including such advanced methods as neural networks or expert systems and techniques that are nondestructive to the beams being monitored); (3) beam diagnostic devices that have increased sensitivities through the use of superconducting components (for example, filters based on high T_c superconducting technology or Superconducting Quantum Interference Devices); (4) measurement devices/systems for cw beam currents in the range 0.1 to 100 μA, with very high precision ($<10^{-4}$) and short integration times; (5) beam diagnostics for ion beams with intensities less than 10^7 nuclei/second; (6) non-destructive beam diagnostics for stored ion beams such as at the RHIC and/or for 100 mA class electron beams; (7) devices that can perform direct 12-14 bit digitization of signals at 0.5-2 GHz and have bandwidths of 100+ kHz; (8) systems for predicting insipient failure of accelerator components through the monitoring/cataloging/scanning of real-time or logged signals; (9) devices/systems that measure the emittance of intense (>100kW) cw ion beams, such as those expected at a future rare isotope beam facility; (10) beam halo monitor systems for ion beams and (11) instrumentation for electron cloud effect diagnostics and suppression..

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

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28. NUCLEAR PHYSICS SOFTWARE AND DATA MANAGEMENT

Large scale data storage and processing systems are needed to store, access, retrieve, distribute, and process data from experiments conducted at large facilities, such as Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) and the Thomas Jefferson National Accelerator Facility (TJNAF). The experiments at such facilities are extremely complex, involving thousands of detectors that produce raw experimental data at rates up to several hundred MB/sec, resulting in the annual production of data sets containing hundreds of Terabytes (TB) to Petabytes (PB). Many 10s to 100s of TB of data per year are distributed to institutions around the U.S. and other countries for analysis. Research on large scale data management systems is required to support these large nuclear physics experiments. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Large Scale Data Storage—Projections of the cost of data storage media show that magnetic disk media will soon be competitive with magnetic tape for storing large volumes of data. Because current technology keeps all disk drives powered and spinning, the infrastructure costs of operating a many-petabyte-scale disk storage system could be prohibitive. However, one characteristic of nuclear physics datasets is that most of the data is accessed infrequently. Therefore, grant applications are sought for new techniques for petabyte-scale magnetic disk systems that are optimized for infrequent data access, emphasizing lower cost and lower power usage. To the extent feasible, it is desirable that the cost should scale with the amount of data accessed rather than the total storage capacity.

Grant applications are also invited for the development of innovative storage technologies that have high reliability and low cost, and are geared toward infrequently-accessed petabyte-scale data.

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

b. Large Scale Data Processing and Distribution—A recent trend in nuclear physics is to construct data handling and distribution systems using web services or data grid infrastructure software – such as Globus, Condor, and Open Grid Services (OGSA), which is based upon Web Services – for large scale data processing and distribution. Grant applications are sought for: (1) hardware and/or software techniques to improve the effectiveness and reduce the costs of storing, retrieving, and moving such large volumes of data, including, but not limited to, automated data replication coupled with application data catalogs, distributed storage systems of commercial off-the-shelf (COTS) hardware, and storage buffers coupled to 10 Gbps (or greater) networks; (2) hardware and/or software techniques to improve the effectiveness of computational and data grids for nuclear physics – examples include integrating the management of distributed open source Relational DataBase Management System (RDBMS) with OGSA, and developing application-level monitoring services for status and error diagnosis; (3) effective new approaches to data mining, automatic structuring of data and information, and facilitated information retrieval; and (4) distributed authorization and identity management systems enabling single sign-on access to data distributed across many sites. Proposed infrastructure software solutions should consider and address the advantages of integrating closely with the OGSA and other new technologies. Applicants that propose data distribution and processing projects are encouraged to contact the Open Science Grid to determine relevance and possible future migration strategies into existing infrastructures.

Grant applications also are sought: (1) to provide redundancy and increased reliability for servers employing parallel architecture, so that they are capable of handling large numbers of simultaneous requests by multiple users; and (2) for hardware and software to improve remote user access to computer facilities at Nuclear Physics research centers, while at the same time providing adequate security to protect the servers from unauthorized access.

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

c. Large Scale Data Archiving and Maintenance—One of the legacies of nuclear physics experiments is the data produced. Large projects like Gammasphere, sited at Argonne National Laboratory (ANL), and experiments at RHIC and TJNAF produce unique data, whose measurements may never be repeated. It may take several years to complete the data analysis and publish the results. Then, in subsequent years, there may be a need to present the data in different forms, in order to facilitate comparison with new theoretical descriptions or newer experimental measurements. Therefore, it is important to preserve these data and their documentation over many years, in the context of potential changes in storage technology and the evolution of experimental groups. Grant applications are sought to develop permanent archiving, data provenance, and user-friendly Internet dissemination procedures for the data from nuclear physics experiments, along with associated detector description and calibration information. A complete data package would include: (1) the raw data and the programs to read and process the data; (2) ROOT trees or n-tuples with derived physics quantities; and (3) documentation, analysis notes, email archives, and web pages that detail the information and procedures used with the data for existing results. Examples of relevant technologies include (but are not limited to) systems for collecting, recording and preserving data-provenance metadata; tools to verify data integrity over long lifetimes; annotation tools; and data access portals to enable searching and retrieving relevant and

related data and metadata. Applicants that propose data archiving projects are encouraged to contact the U.S. National Nuclear Data Center to determine relevance and possible future migration strategies into existing infrastructures.

Grant applications also are sought for hardware and/or software techniques to implement massive and automated backup solutions, in order to protect valuable experimental data and programs from disk failures.

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

d. Distributed Processing—Large scale (thousands of CPU's) computing platforms are needed to perform theoretical calculations of Lattice Quantum ChromoDynamics (LQCD), a method of extracting the predictions of the fundamental theory of the interactions of quarks. While this science application can use virtually any supercomputer architecture efficiently, the computational demands are such that the cost effectiveness of the platform (measured in floating point operations per second per dollar, as sustained by a large scale parallel application) is a significant consideration. Clusters are an appropriate platform for these calculations because of their low cost-per-compute node, but only if the cluster interconnects were of high bandwidth, low latency, and low cost. Although current offerings fall short on at least one of these metrics, the science applications are such that nearest-neighbor communications predominate in a three- or four-dimensional torus; therefore, a fully interconnected switch fabric is not essential – a torus mesh with routing also would be a feasible design. Grant applications are sought to develop mesh-communication-optimized cluster interconnects that are scalable to thousands of nodes at modest cost. The interconnects must be well coupled to next generation commodity compute nodes (to achieve high bandwidth and low latency on future systems) and must have a cost well below the cost of the compute node.

In a related development, grid computing is an emerging mode, sometimes called "computing on demand," of supporting the highly distributed and intensive scientific computing for nuclear physics (and other sciences). Consequently, there is a need for software distribution and installation mechanisms that can be automated and scaled to the large numbers (100s) of computing facilities distributed around the country and the globe. Such software solutions would enable rapid access to computing resources as they become available to users who do not have the necessary application software environment installed. Grid deployments such as the Open Science Grid (OSG) in the U.S. and the LHC Computing Grid (LCG) in Europe provide standardized infrastructures for scientific computing across large numbers of distributed facilities. Grant applications are sought to develop mechanisms and tools that enable efficient and rapid packaging, distribution, and installation of nuclear physics application software on distributed computing facilities such as the OSG and LCG.

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

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PROGRAM AREA OVERVIEW
OFFICE OF HIGH ENERGY PHYSICS

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

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

Experimental research in HEP is largely performed by university scientists using particle accelerators located at major laboratories in the U.S. and abroad. Under the HEP program, the Department operates the Fermi National Accelerator Laboratory (Fermilab) near Chicago, IL and the Stanford Linear Accelerator Center (SLAC) near San Francisco, CA. Furthermore, the Department has a significant role in the Large Hadron Collider project under construction at the CERN laboratory in Switzerland. The Tevatron Collider at Fermilab is currently the world's highest energy accelerator. The Fermilab complex also includes the Main Injector, which can be used independently of the Tevatron to create high-energy particle beams for physics experiments and R&D work, including the world's most intense neutrino beam. SLAC is dedicated to the design, construction and operation of state-of-the-art electron accelerators and related facilities for use in high-energy physics, condensed matter research, and related fields. SLAC HEP facilities include the 2 mile long Stanford Linear Accelerator and a high energy, high intensity electron-positron collider. While much progress has been made during the past five decades in our understanding of particle physics, future progress depends on a great degree of availability of new state-of-the-art technology for accelerators, colliders, and detectors operating at the high energy and/or high intensity frontiers.

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

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

29. HIGH ENERGY PHYSICS DATA ACQUISITION AND PROCESSING

The DOE supports the development of advanced electronics and computational technologies for the recording, processing, storage, distribution, and analysis of experimental data that is essential to experiments and particle accelerators used for High Energy Physics (HEP) research. Areas of present interest include event triggering, data acquisition, scalable clustered computer systems, distributed collaborative infrastructure, distributed data management and analysis frameworks, and distributed software development useful to HEP experiments and particle accelerators. Grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities.

Although particle physics detector instrumentation, data processing and analysis, and software development typically occur in large collaborative efforts at national particle accelerator centers, there are efforts where small businesses can make innovative and creative contributions to further development of the required advanced technologies. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. On-line directories of appropriate researchers are available by institution at http://www.hep.net/sites/directories.htlml. **Grant applications are sought only in the following subtopics:**

a. High-Speed Electronic Instrumentation—Grant applications are sought to develop components, electronics, systems, and instrumentation modules as follows:

(1) Special purpose chips and devices are sought for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, pico-second resolution time-to-digital converters, controllers, and communications interface devices.

(2) Circuits and systems are sought for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, particle calorimeters, and Cerenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters (>300 MHz), and time-to-amplitude converters. Compatibility with one of the widely used module interconnection standards (e.g., VMEbus, PCIExpress, or high

speed serial interfaces) is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

(3) Advanced, high speed logic arrays and microprocessor systems are sought for fast event identification, event trigger generation, and data processing with very high throughput capability. Such systems should be compatible with or implemented in one of the widely used module interconnection standards (e.g., VMEbus, PCIExpress, or high speed serial interfaces).

(4) Much of the electronics instrumentation in use in HEP is packaged in one of the international module inter-connection standards (e.g., VMEbus, PCIExpress, or high speed serial interfaces). Therefore, grant applications are sought for modules that will provide capabilities not previously available; for substantial performance enhancement to existing types of modules; and for components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, interconnection systems, communication modules and systems, and disk-drive interface modules.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

b. Large Scale Analysis Computer Systems—The Office of High Energy physics seeks grant applications to develop:

(1) computer system components and supporting software enabling cost-effective and reliable use of petabyte-scale storage networks, especially for magnetic disks, optical disks, and magnetic tapes;

(2) computer system components and supporting software enabling the use of transport protocols in a more efficient manner over local and wide area networks;

(3) improvements to the reliability of cybersecurity systems protecting distributed storage systems; and/or

(4) improvements to the reliability and performance of wide area networks.

Proposed efforts must address identified computing problems related to diverse, large scale computing systems that support particle physics data processing and analysis.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

c. Distributed Collaborative Infrastructure and Distributed Data Management and Analysis Frameworks—Advanced computational tools and software are needed to strengthen the ability of dispersed particle physics researchers to collaborate and to address problems related to the acquisition, handling, storage, analysis, and visualization of large datasets by these distributed collaborations. Grant applications are sought to develop:

(1) client-server frameworks and Web tools for creating collaborative environments, facilitating remote participation of detector experts at the data collection stage, and/or allowing collaborators real-time two-way participation in remote meetings;

(2) software project management tools;

(3) computer system components and supporting software incorporating the use of Quality of Service features generally available in wide area networks;

(4) portable systems to hold very large collections of data of the type created in connection with the operation of very large detectors, along with data management tools;

(5) visualization and software environments appropriate for physics analysis;

(6) software to support data systems distributed over a wide area network;

(7) framework, interconnects, and other peripherals which allow the use and orderly aggregation of commodity computers and computer peripherals at larger than normal scales, or at higher performance levels than usual;

(8) software development tools for the production of computer software to meet identified problems related to distributed, large scale software development, configuration management, and data analysis – approaches of interest include distributed portable testing and Computer Aided Software Engineering, including configuration management tools for a portable, distributed environment;

(9) Web tools for remote data selection ("skimming"); and

(10) Algorithms and software tools for pattern recognition and optimization of data analysis.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

d. **Simulation and Modeling Techniques and Systems—**Grant applications are sought to develop advanced computing tools and software for high energy physics simulation and modeling. Topics of interest include simulation and modeling algorithms for high energy physics processes, particle detectors, and theoretical calculations. Applications are also sought in areas of simulation support such as frameworks for the management, configuration, custody, and dissemination of simulation and modeling data to enable sharing by multiple experiments and theory research groups.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

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30. ACCELERATOR TECHNOLOGY FOR THE INTERNATIONAL LINEAR COLLIDER

The DOE High Energy Physics (HEP) program supports research and development for the International Linear Collider (ILC), a 500 GeV superconducting linear electron-positron collider that will probe the energy frontier with unprecedented precision. Advanced R&D is needed in support of this project in: (a) 1.3 GHz superconducting radiofrequency (SRF) systems, (b) beam instrumentation and feedback systems, (c) magnet and fast kicker technology, (d) polarized radiofrequency (RF) photocathode sources, and (e) high reliability magnet, magnet power supply, and associated control systems. Relevance to the ILC must be explicitly described. **Grant applications are sought only in the following subtopics:**

a. Superconducting Radiofrequency Systems—Research is needed in a variety of superconducting RF areas to support the development of the ILC. Accordingly, grant applications are sought:

(1) to develop high gradient, 1.3 GHz superconducting RF cavities, with application to the accelerating structures needed for the ILC. Multi-cell cavities, with accelerating gradients greater than 35 MV/m and Q-factors greater than 5×10^9, are of particular interest. Priority areas of research focus include new cavity geometries, new materials (e.g., large grain or single crystal Nb), improved methods of cavity fabrication, advances in surface preparation and processing (particularly in electropolishing), improved control of field emission, and suppression of high-field Q-slope. Research areas which provide the promise of significant results in the next few years and techniques that are suitable for automation and industrialization are preferred.

(2) for technology to support the development of fundamental power couplers and tuners for 1.3 GHz SRF cavities. Areas of interest include improvements to current coupler design (resulting in reduced conditioning time, reduced cost, and improved reliability), new tuner designs and concepts for both fast and slow tuning, as well as inexpensive broad-band 2K microwave absorbing material with repeatable electrical properties for HOM damping and resonance suppression.

(3) to develop high efficiency 1.3 GHz modulators and klystrons, capable of operation at peak power levels on the order of 10 MW, with a pulse width of 1-3 ms, at a repetition rate of 5-10 Hz. The modulator efficiency should be greater than 75%, and the klystron efficiency should be greater than 65%. Modulator designs with a small physical footprint, a high reliability, and capable of delivering high voltage pulses suitable for direct coupling to the klystron, are of greatest interest. Grant applications also are sought to develop power distribution systems suitable for the transport of L-band microwave power at the level of 10 MW (peak).

(4) to develop digital, low-level RF 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 capable of doing vector sum control on ILC cryomodules, thus allowing each cavity to be run at its full potential, are of interest.

(5) to develop SRF cavity processing technology (such as electropolishing) to clean and improve the smoothness of the surface of multi-cell niobium (Nb) cavities; and advanced cleaning and handling techniques to eliminate particulate contamination as a source of field emission in the cavities. The processing technology should be able to demonstrate an improvement in the accelerating gradient of the cavities.

(6) for research and development leading to the design and fabrication of ILC cryomodules for 1.3 GHz superconducting cavity strings. Each ILC cryomodule contains several 1.3 GHz cavities and couplers in their He vessels, quadrupoles, tuners, as well as a 2K helium distribution system. Improvements in cryomodule design and fabrication which will result in lower cost are of particular interest.

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

(8) to develop technologies to facilitate the installation, support, and alignment of very large accelerator beam line lattice elements.

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

b. Beam Instrumentation and Feedback Systems—Instrumentation and feedback systems are needed to support the development of the ILC. Accordingly, grant applications are sought to develop:

(1) fast transverse feedback systems, appropriate for controlling vertical beam jitter at the 0.1 sigma level, in linear colliders with long bunch trains (on the order of 1 ms). Areas of particular interest include systems with bandwidth sufficient to control single bunches within a train (with a bunch separation of order 100 ns), and systems that can operate on a train-by-train basis (with a train repetition period of order 5 Hz). System design should be based on the bunch parameters of the ILC.*

(2) linac beam position monitoring systems capable of single-bunch position resolution in the range of 1-10 μm (rms). High precision beam position monitors for the damping rings and beam delivery system are also of interest. The system design must be relevant for the bunch parameters of the ILC.*

(3) high resolution beam profile monitoring systems capable of measuring the emittance of a high energy electron/positron beam, with the bunch parameters of the ILC.* The emittance should be measured with an accuracy of 10% or better.

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

c. Magnet and Fast Kicker Technology—Advanced magnet and fast kicker technologies are needed to support the development of the ILC. Accordingly, grant applications are sought to develop:

(1) wiggler systems suitable for use in the damping rings of the ILC. Both permanent magnet and superconducting magnet systems are of interest. Over one damping time, the uniformity of the wiggler field must be sufficient to provide a dynamic aperture of approximately 10 sigma, as determined by tracking particles characteristic of the injected positron beam. The wiggler physical aperture must provide an acceptance of approximately 5 sigma.

(2) fast kicker systems useful for single bunch injection/extraction systems in the ILC damping rings. The rise and fall time of the field seen by the beam must be close to 3-4 ns. The overall system (possibly consisting of a number of kicker modules) should be capable of delivering a 0.6 mrad kick to a 5 GeV electron beam. The kicker should be capable of burst operation at 3 MHz for a duration of up to 1 ms, at a repetition rate of 5 Hz.

(3) short-period helical undulators, suitable for use with a high-energy (>150 GeV) electron beam, to produce an intense 10 MeV photon beam. (The photons subsequently would be used to produce showers in a thin target, providing an undulator-based positron source for the ILC.) The undulator field, gap, and period must be consistent with the requirements of the ILC undulator-based source.*[reference 1]

(4) quadrupole focusing systems, capable of achieving the demagnification needed at the interaction point of the ILC, while satisfying the geometry constraints imposed by the beam crossing angle and the particle detectors. [reference 2]

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

d. Polarized RF Photocathode Sources and Accelerator Magnet Technology—Grant applications are sought for the development of polarized electron sources which operate with RF guns, and consequently can provide very low emittance beams. The cathode material should have long lifetime

and high quantum efficiency, and electron polarization must be greater than 85%, with an rms invariant emittance of 4π□mm-mrad or less. The bunch parameters and format should be those of the ILC.*

Grant applications are also sought for the development of water cooled accelerator magnets with an extremely high reliability, characterized by a mean time to failure of greater than 10 million hours. Highly reliable power supply systems for accelerator magnets are also needed, with a mean time to failure of greater than 4 million hours. Associated high reliability electronic control systems will also be needed.

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

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* The ILC linac parameters include a beam intensity of $2x10^{10}$ electrons or positrons per bunch, in trains of about 3000 bunches, separated by about 300 ns. The trains themselves occur at a repetition rate of 5 Hz. Each bunch has an rms invariant transverse emittance of about 8 μm (horizontal) by 0.02 μm (vertical), with an rms bunch length of 300 μm. Beam size at the IP is about 6 nm vertically. The energy varies from 5 GeV at the start of the linac, to 250 GeV at the end.

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31. ADVANCED CONCEPTS AND TECHNOLOGY FOR HIGH ENERGY ACCELERATORS

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in the following areas: (1)

new concepts for acceleration, (2) novel device and instrumentation development, (3) inexpensive electron sources, and (4) computer software for control systems and advanced accelerator modeling. Relevance to applications in HEP must be explicitly described in the submitted grant applications. Advanced accelerator R&D more appropriate to applications in nuclear physics is specifically excluded from this topic and should be submitted under Topic 27. **Grant applications are sought only in the following subtopics:**

a. New Concepts for Acceleration—Grant applications are sought to develop new or improved acceleration concepts. Designs should provide very high gradient (>100 MV/m for electrons or >10 MV/m for protons) acceleration of intense bunches of particles, or efficient acceleration of intense (>50 mA) low energy (of order <20 MeV) proton beams. One possible concept might be 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 of 1 to 2.5 μm. For all proposed concepts, stageability, beam stability, manufacturability, and high-wall plug-to-beam power efficiency should be considered.

Grant applications are also sought for demonstration of proton acceleration in the energy range of a few GeV using non-scaling fixed field alternating gradient accelerators (FFAG). This may require an electron model to directly simulate operation in space charge limitation and fast RF modulation for high repetition rate. The HEP application of interest is for a proton driver injector for a neutrino factory. Possible other applications are high intensity proton drivers for neutron production, waste transmutation, for energy production in sub-critical nuclear reactors, medical proton therapy (250 MeV), and radioisotope production.

New concepts for generation, capture, cooling, acceleration and colliding of intense muon beam are also of interest.

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

b. Novel Device and Instrumentation Development—Grant applications are sought for the development of electromagnetic, permanent magnet, or silicon microcircuit-based charged particle optical elements for particle beam focusing. Examples include, but are not limited to, dipoles, quadrupoles, higher order multipole correctors for use in electron linear accelerators, and solenoids for use in electron-beam or ion-beam sources or for klystron or other radio frequency amplifier tubes operating at wavelengths from 0.7 to 10 cm. In these optical elements, permanent magnets or hybrid magnets incorporating magnetic materials that have very high residual magnetization, radiation resistance, and thermal stability (low variation of field strength with temperature) are of particular interest. Also of interest are undulators for bunching high energy electron beams, needed for phased injection in high frequency accelerating structures and for generating coherent transition radiation.

Grant applications are also sought for: (1) novel charged particle beam monitors to measure the transverse or longitudinal charge distribution, emittance, or phase-space distributions of small radius (0.1 μm to 5 mm diameter), short length (10 μm to 10 mm) relativistic electron or ion beams; (2) devices capable of measuring and recording the Schottky or transition radiation spectrum of these beams (proposed techniques should be nondestructive, or minimally perturbative, to the beams monitored and have computer-compatible readouts); (3) lasers for laser-accelerator applications that provide substantial

improvements over currently available lasers in one or more of the following parameters: (i) longer wavelengths (up to 2 to 2.5 μm for use with Si transmissive optics), (ii) very short wavelengths (< 200 nm) with low mode numbers (M-squared < 100) and high pulse energy (> 0.1 J) for photo-ionized plasma sources, (iii) higher power, (iv) higher repetition rates, and (v) shorter pulse widths; and (4) achromatic, isochronous compact focusing systems with broad energy acceptance and compact broadband (10-100 MeV) spectrometers, suitable for use in laser acceleration experiments.

Grant applications are sought to develop high density (range of 10^{18}-10^{20} cm^{-3}), high repetition rate (≥10 Hz) pulsed gas jets, capable of producing longitudinally tailored density profiles with long lengths (centimeter scale) and narrow widths (few hundred microns) for use in laser wakefield accelerators. The gas jet should have sharp entrance gradients, with a transition region/length on the order of 500 μm. The pulse duration of the jets should be less than 500 μs to minimize the amount of gas loading in vacuum chambers. Cluster gas jets, i.e., jets that are cooled and produce atomic clusters, are also of interest.

Grant applications also are sought for the development of novel devices and instrumentation for use in producing intense low energy muon beams suitable for precision muon experiments, and intense high energy muon beams suitable for neutrino factories and/or muon colliders. Approaches of interest include the development of: (1) concepts or devices for ionization cooling, including emittance exchange processes; (2) concepts or devices for manipulating the longitudinal phase space of large emittance muon beams, including bunching, phase rotation, and bunch merging; (3) concepts or devices for producing intense polarized muon beams; (4) large aperture kicker for injection and extraction in muon cooling rings; (5) concepts for cost effective rapid acceleration; (6) instrumentation for muon cooling channels that have muon intensities of 10^{12} muons/pulse; or (7) fast (on the order of 10 picosecond) timing detectors for muon cooling experiments with low muon intensity (on the order of 10^5 muons/second).

The non-scaling Fixed Field Alternating Gradient (FFAG) systems are becoming of interest for many applications, including muon acceleration for a neutrino factory. Grant applications are sought for (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.

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

c. Inexpensive High Quality Electron Sources—Grant applications are sought for the design and prototype fabrication of small, inexpensive (<$1 million) electron sources for use in advanced accelerator R&D laboratory experiments. The following parameters are target values for accelerator research experiments: (1) energy range of 5 to 35 MeV providing, at a minimum, on the order of 10^9 electrons in a bunch less than 5 picoseconds long; (2) normalized transverse beam emittance ≤5π mm-mrad; and (3) pulse repetition rate >10 Hz. Grant applications are also sought for sources with significantly lower bunch charges, energies, and emittances from a matrix cathode, but at comparable or greater peak currents and significantly higher repetition rates. In addition, grant applications are sought to develop a bright direct-current/radio-frequency (DC/RF) photocathode electron source that combines

a pulsed high-electric-field DC gun and a high field RF accelerator, operates at a repetition rate of several kHz, and has electron bunch specifications similar to those listed above.

Grant applications are also sought for the development of robust RF photocathodes (quantum efficiencies >0.1 percent) or other novel RF gun technologies operating at output electron beam energies >3 MeV. Also of interest are laser or electron driven systems for such guns.

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

d. Computer Software for Control Systems and Advanced Accelerator Modeling—Grant applications are sought to develop new or improved computational tools specifically for the design, study, or operation of charged-particle-beam optical systems, accelerator systems, or accelerator components. Such applications should incorporate the innovative development of user-friendly interfaces, with emphasis on graphical user interfaces and windows. Grant applications are also sought for the conversion of existing codes to incorporate such interfaces, provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate.

Grant applications 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. Improved simulation packages also are of interest for the ionization cooling of muon beams, for instance, by modifying the scattering algorithms to improve agreement with new experimental data.

Grant applications are also sought to develop: (1) improved software systems for command and control functions, real time database management, real-time or off-line modeling of the accelerator system and beam, and status display systems encountered in state-of-the-art approaches to accelerator control and optimization; and (2) improved decision and database management tools, specifically for use in planning and controlling the integrated cost, schedule, and resources in large HEP R&D and construction projects.

Grant applications are also sought to develop real-time optical networks for pulsed-accelerator control. These networks require timing information to be combined with data-communication functions on a single optical fiber connected to pulsed device-controllers. The single fiber should provide each controller with an RF-synchronized clock that has the following features: (1) an arrival time that is phase-locked to the temperature-stabilized RF reference phase, (2) a phase-locked machine pulse fiducial point, (3) digital data for machine pulse-type selection and specific pulse identification, and (4) real-time-streaming pulsed waveform data-acquisition capabilities. The controllers serve as interfaces to systems that provide such functions as low-level RF signal generation, modulator control, beam position monitors, and machine protection system sensing. The network should provide real-time, fast-feedback loop closure and TCP/IP connectivity for slow control functions, such as database access, device configuration, and code downloading and debugging.

Finally, grant applications are sought to develop real-time processors and software for pulsed accelerator control and monitoring. The software should be based on a multiprocessor architecture that can be deeply embedded within pulsed device-controllers, which employ system-on-a-chip, field-programmable gate-array, or application-specific integrated circuit technologies. The architectures should feature distinct processors for real-time pulse-to-pulse functions, and conventional slow control functions. Architectural provisions for supporting machine protection functions via an additional processor or dedicated hardware also should be included.

For the preceding two paragraphs, proposed solutions should be engineered to include: (1) resistance to electromagnetic interference generated by nearby, large, pulsed-power systems; and (2) maximum availability in remote deployment locations.

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

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

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

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in: (1) high gradient accelerator structures, (2) high peak power radio frequency (RF) technologies, and (3) new concepts for low-cost, very efficient, pulse power modulators. Relevance to applications in HEP must be explicitly described. RF accelerator R&D more appropriate to applications in nuclear physics is specifically excluded from this topic and should be submitted under Topic 27. **Grant applications are sought only in the following subtopics:**

a. Radio Frequency Acceleration Structures—Grant applications are sought for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >150 MV/m for electrons and >10 MV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and reducing costs. In

muon accelerator R&D, structures for capture and acceleration of large emittance muon beams and techniques for achieving gradients of 5-20 MV/m in cavities with frequencies between 5 and 400 MHz (including superconducting cavities whose resonant frequencies can be rapidly modulated) are of interest. Methods for reducing surface breakdown and multipactoring (such as spark-resistant materials or surface coatings, or special geometries) and for suppressing unwanted higher order modes also are of interest, as are studies of surface breakdown and its dependence on magnetic field. Grant applications should be applicable to devices operating at frequencies from 1 to 40 GHz, or between 5 and 400 MHz for muon accelerators.

Grant applications are also sought to develop simulation tools for modeling high-gradient structures, in order to predict such experimental phenomena as the onset of breakdown, post breakdown phenomena, and the damage threshold. Specific areas of interest include the modeling of: (1) surface emission, (2) material heating due to electron and ion bombardment, (3) multipactoring, and (4) ionization of atomic and molecular species. Approaches that include an ability to import/export CAD descriptions, a friendly graphical user interface, and good data visualization will be a plus.

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

b. Radio Frequency Power for Linear Accelerators—Grant applications are sought to develop new concepts, high-power RF components, and instrumentation for use in producing high peak power in narrow-band, low-duty-cycle, and low-pulse-repetition-frequency (approximately 0.1 to 1 kHz) pulsed RF amplifiers. The principal application will be for future large multi-TeV electron/positron linear colliders. Of particular interest are innovations related to cost saving, manufacturability, and electrical efficiency. Also of interest are RF sources for high-gradient accelerator research.

Grant applications are sought for the development of RF sources at K- to Ka-band, with a power level of ~50 MW, a pulse width of ~1 μs, and a repetition rate of 100 Hz. The frequency stability and output spectrum must be suitable for driving a linac. Innovations that allow the source to be configured for different frequencies at low cost are of particular interest. In addition, grant applications are sought to develop electron beam sources, such as sheet or elliptical beams, relevant to the abovementioned high power RF applications.

The next generation of multi-TeV linear colliders will require many RF power handling components which are not presently available, e.g., RF windows, couplers, mode transformers, RF loads, and high power rings capable of operating at high pulse powers. Consequently, grant applications are sought to develop active or passive RF pulse compression systems capable of handling peak powers of 150-200 MW and 100-200-nanosecond pulsewidth at 30 GHz. Grant applications are also sought for passive and active RF components such as over-moded mode converters (e.g., rectangular to circular waveguide and vice versa), high-power RF windows, circulators, isolators, switches, and quasi-optical components.

Lastly, grant applications are sought for new concepts, approaches, or designs for radio-frequency amplifiers, or pulse compression schemes, for use in the acceleration and ionization cooling channels of a future muon collider. The amplifiers or compressors must have high peak power (>30 MW) and pulsed, low frequency (from 2 ms pulses at 20 MHz to 0.1 ms pulses at 200 MHz). Higher power (>100 MW) pulsed sources at higher frequencies, e.g., 30 μs at 400 MHz, also are of interest. All muon

collider amplifiers must have moderate repetition rate capability (e.g., 15 Hz). Grant applications should address the cost per unit of peak power, including the cost of required power supplies.

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

c. New Concepts or Components for Pulsed Power Modulators and Energy Storage—Most RF power sources for future linear colliders require high peak-power pulse modulators of considerably higher efficiency than presently available. Grant applications are sought for new types of modulators in the 400 kV – 1 MV range for driving currents of 200 - 800 A, with pulse lengths of 0.2 – 5.0 μs, and with rise- and fall-times less than 0.5 μs. Grant applications also are sought for the development of modulators with improved voltage control for RF phase stability in some alternate RF power systems, as well as cathode modulators that are compact and cost competitive compared to present cathode pulse modulator schemes. Grant applications should address issues related to cost saving, manufacturability, and electrical efficiency in modulators.

Grant applications are also sought to develop improved high power solid-state switches for pulse power switching. For some applications, requirements will include the ability to switch high current pulses (2-5 kA) at voltage levels of 2 to 6 kV with switching times less than 300 nsec. These switches must handle very high di/dt (20 kA/μs) at low duty cycle (<0.1%).

Existing Insulated Gate Bipolar Transistor (IGBT) packages for high voltage and high pulsed current (e.g. V > 3.3kV, I > 3 kA peak, 59 A average) are not optimized for very high speed pulsed power applications (6.6 MW peak for 3.2 μs at 120 Hz) due to failure modes induced by very rapid fall times (di/dt >10 kA/μs) and/or rise times (dV/dt >15 kV/μs) upon device turn-off. Therefore, grant applications are sought to reduce these failure modes through improved packaging of commercial IGBT chips, by incorporating appropriate protective circuitry in a high voltage power package designed specifically for high-speed transients.

Lastly, grant applications are sought to develop and optimize high reliability, high-energy-density energy storage capacitors for future solid state pulse power systems. The capacitors must: (1) deliver high peak pulse current (5 - 8 kA) in the partial discharge region (less than 10 percent voltage droop during pulse); (2) be designed with very low inductance connections to allow fast rise and fall time discharge without ringing (di/dt ~ 20 kA/μs); and (3) be packaged to meet the requirements of high power solid state board layouts and have minimum production cost.

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

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33. HIGH-FIELD SUPERCONDUCTOR AND SUPERCONDUCTING MAGNET TECHNOLOGIES FOR HIGH ENERGY PARTICLE COLLIDERS

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in high-field

superconductor and superconducting magnet technologies. This topic addresses only those superconductor and superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems. **Grant applications are sought only in the following subtopics:**

a. High-Field Superconductor Technology—Grant applications are sought to develop new or improved superconducting wire technologies for magnets that operate at a minimum of 12 Tesla (T) field, with increases up to 15 to 20 T sought in the near future (three to five years). Vacuum requirements in accelerators and storage rings favor operating temperatures of 1.8 to 20 K. Stability requirements for magnets dictate that the effective filament diameter should be less than 30 micrometers. Upgrades of existing particle accelerators will require some magnets that operate under a high radiation (and thermal) load. New or improved technologies must demonstrate: (1) property improvements such as higher critical current densities and higher upper critical fields, (2) the manageable degradation of these properties as a function of applied strain, and (3) low losses in changing transverse magnetic fields, such as for twisted round multifilamentary wires. Any proposed process improvements must result in equivalent performance at reduced cost. All grant applications must focus on conductors that will be acceptable for accelerator magnets, especially with regard to the operating conditions mentioned above, and must address plans to physically deliver a sufficient amount of material of 1 km minimum length for winding and testing in small dipole or quadrupole magnets.

Grant applications are also sought to develop improvements in the starting raw materials and the basic superconducting materials for niobium-titanium (Nb-Ti) alloys, A-15 compounds (such as Nb_3Sn and Nb_3Al), high-temperature superconductors (HTS; such as $Bi_2Sr_2CaCu_2O_8$ and $YBa_2Cu_3O_{7-\delta}$), and magnesium diborides (MgB_2 and its alloyed variants). *Regarding Nb-Ti alloys:* High performance Nb-Ti alloys operating above 8 T continue to be required for focusing quadrupole magnets or for graded windings in the low-field portions of high-field magnets; therefore, grant applications are sought to develop Nb-Ti composite superconductors with properties optimized at 8 T fields and higher at 4.2 K. *Regarding A-15 compounds:* A minimum current density of 1800 A mm^{-2} at 15 T and 4.2 K must be achieved in the superconductor itself. *Regarding HTS:* 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. *Regarding MgB_2:* present wires are characterized by a filling factor that is too low, wire cross-sections that have too few filaments, and upper critical and irreversibility fields that are too low therefore, grant applications should seek to improve the current density over the wire cross-section, implement restacked round-wire multifilamentary designs, and extend the field at which a critical current density can be attained over the superconductor cross-section of 1200 A mm^{-2} in the 12-16 T range at 4.2 K.

Grant applications are also sought to develop: (1) innovative wire processing technologies, and (2) innovative insulating materials that are compatible with the use of intermetallic superconductors in practical devices. Innovative wire processing technologies of interest include methods to utilize stranded conductors with high aspect ratio, such as Rutherford cables, or low-loss tape geometries in particle accelerator applications; technologies to improve wire piece length and increase billet mass also are of interest. Innovative insulating materials should enable the use of intermetallic superconductors, such as the A-15, HTS, or MgB_2 types, in practical devices. Insulating systems must: be compatible with high temperature reactions in the 750-900 ºC range; be capable of supporting high mechanical

loads at both room and cryogenic temperatures; have a high coefficient of thermal conductivity; be resistant to radiation damage; and exhibit low creep and low out-gassing rates when irradiated.

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

b. Superconducting Magnet Technology—Grant applications are sought to develop: (1) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (2) improved current leads based on high-temperature superconductors for application to high-field accelerator magnets, which have requirements that include an operating current level of 5 kA or greater, stability, low heat leak, and good quench performance; (3) alternative designs, to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets, that may be more compatible with the more fragile A-15, and the HTS, high-field superconductors; (4) designs for bent (e.g., bending radius in the range 0.75 to 1.25m) solenoids (e.g., 2 T, 30 cm inside diameter) with superimposed dipole fields (e.g., 1 T) for dispersion generation in large emittance beams; (5) improved industrial fabrication methods for magnets such as welding and forming; or (6) improved cryostat and cryogenic techniques.

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

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7. "The 2002 Applied Superconductivity Conference," Houston, TX, August 4-9, 2002, *IEEE Transactions on Applied Superconductivity,* 3 parts, 13(2), June 2003. (ISSN: 1051-8223)

8. "The 2004 Applied Superconductivity Conference," Jacksonville, FL, October 3-8, 2004, *IEEE Transactions on Applied Superconductivity,* 3 parts, 15(2), June 2003. (ISSN: 1051-8223)

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

34. 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 which can be used in novel ways as a consequence of associated technological developments in electronics (e.g., sensitivity or bandwidth), with particular interest in devices exhibiting insensitivity to very high radiation levels. Also of interest are novel experimental systems that use new detectors, or use old ones in new ways, that either extend basic HEP experimental research capabilities or result in less costly and less complex apparatus. 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. **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), gas or liquid-filled chambers (used for particle tracking or in electromagnetic or hadronic calorimeters, Cherenkov or transition radiation detectors). Applications are also sought for systematic studies of radiation aging of materials used in particle detectors.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

b. Detector Support and Integration Components—HEP experiments frequently require high performance detector support that will not compromise the precision of the detectors. Therefore, grant applications are sought for components used to support or integrate detectors into HEP experiments.

The support components must be well matched to the detectors and possess some or all of the following features: low mass, high strength or stiffness, low intrinsic radioactivity, exceptionally high or exceptionally low thermal conductivity, and low cost. Grant applications also are sought for alignment systems, cooling systems, and radiation-hard low voltage power supplies for digital and analog electronics.

The 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** (e.g., radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost). 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.

Questions - contact Saul Gonzalez (saul.gonzalez@science.doe.gov)

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OFFICE OF SCIENCE (Joint Topic with Nuclear Energy, Biological and Environmental Research. High Energy Physics, and Advanced Scientific Computing Research)

35. ADVANCED COMPUTATIONAL METHODS FOR APPLIED SCIENCES AND ENGINEERING

The Office of Science (SC) supports fundamental research programs in basic energy sciences, biological and environmental sciences, and computational science. SC manages this research portfolio through six interdisciplinary program offices: Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES), Biological and Environmental Research (BER), Fusion Energy Sciences (FES), High Energy Physics (HEP), Nuclear Physics (NP), and Nuclear Energy and Technology (NE). Researchers in these areas have achieved key scientific insights in a number of areas of national importance; however, many challenges in applied sciences and engineering are now facing DOE programs that require advanced modeling and simulation capabilities on petascale computers. Another challenge facing DOE programs is driven by the need for capture, storage, transmission, sharing and analysis of large-scale experimental and observational data, as well as data from simulations. This topic is seeking applications that fully integrate ASCR's applied mathematics, computer science, and computational science in the areas of physical, biological and environmental sciences, and nuclear energy to solve practical problems at the petascale level, and a new generation of data management and knowledge discovery tools for the large data sets obtained from large experimental facilities and from high end simulations. Grant applications are sought that: (1) Address obtaining significant insight into, or actually solving challenging problems of national engineering significance related to DOE missions through computational science; and (2) Integrate computational engineering with discipline-driven applications and technologies through teaming and partnerships with computer scientists and applied mathematicians. These activities are supported by a *Scientific Computing Hardware* Infrastructure that will evolve to meet the needs of the science programs. Computing allocation in SC at the National Energy Research Scientific Computing Center (NERSC) and the National Leadership Computing Facilities (NLCF) at Oak Ridge National Laboratory and Argonne National Laboratory could be made available to applications that require stable computing facilities. Grant applications must clearly identify domain-specific applied science problems and the corresponding computational science tools and methods to be used. **Grant applications are sought only in the following subtopics:**

a. Computational Methods for Nuclear Energy and Technology—Nuclear power provides over 20 percent of the U.S. electricity supply without emitting harmful air pollutants, including those that may cause adverse global climate changes. New advanced computational methods algorithms are needed to address specific modeling and simulation issues that affect the future deployment of nuclear energy in current and future reactor designs. This subtopic addresses key advanced computational methods needed for nuclear analyses and improvement in nuclear reactor technology. Grant applications focusing on the application of computational methods to nuclear energy are sought by the Office of

Advanced Scientific Computing Research and the Office of Nuclear Energy. Improvements and advances are needed for simulating reactor systems and component technologies that ultimately would be used in the design, construction, or operation of existing and future nuclear power plants, advanced fast reactors, and Generation IV nuclear power systems [see references]. Grant applications are sought for advanced computational methods that involve advanced reactor/core computer simulations sought for nuclear energy technology including: (a) reactor/core computer simulation methods for existing light water reactor designs; (b) advanced reactor design model code development; coupled/parallel thermal-hydraulic-reactor physics tools; safety and performance evaluation methods and engineering calculations for ***new*** Generation IV reactor designs, reactors, major reactor components, and reactor core and fuel assemblies; (c) ***ab initio*** nuclear cross section/ nuclear data development methods, for Generation IV and GNEP reactor designs; and (d) advanced graphic user-interfaces (GUIs) that use existing nuclear computer codes and simulation methods for large-scale and petascale computers. Grant applications that address the following areas of investigation are **NOT** of interest and will be declined: generalized thermal-hydraulics analysis (e.g. CFD or two-fluid codes) and probabilistic risk assessment tools or methods.

Questions – contact Madeline Feltus, NE Office (Madeline.Feltus@nuclear.energy.gov) or Thomas Ndousse, ASCR Office (tndousse@er.doe.gov)

Subtopic a References:

6. "What's News," U.S. DOE Office of Nuclear Energy, home page, at http://www.nuclear.gov

7. "Generation IV Nuclear Energy Systems," Office of Nuclear Energy Website, at http://gen-iv.ne.doe.gov/

3. "Advanced Fuel Cycle Initiative (AFCI)," Annual Report 2003. (Available at: http://nuclear.gov/reports/AFCIAnnualRpt03.pdf

4. "Global Nuclear Energy Partnership (GNEP)," U.S. DOE Website, at http://www.gnep.energy.gov

b. Computation Bio-Informatics—The processing of genome scale data sets being generated by experimental groups is a core Genomes to Life (GTL) need. Software for identifying protein modifications from mass spectra of trypsinized proteomic samples is a current need. Grant applications are sought to improve one or more of the component software packages that have already been developed by laboratory groups, in order to enhance user friendliness and thereby support their broad export to the biologist community. Grant applications also are sought to develop novel software in support of cellular modeling tasks. Of particular interest are approaches related to: (1) systems biology, (2) the processing of proteomics and metabolomics data sets, (3) improved integration and or querying of heterogenous data sets, and (4) the automated development of cellular metabolic models from data sets on newly studied microbes.

Questions – contact Marvin Stodolsky, BER Office (Marvin.Stodolsky@science.doe.gov) or Thomas Ndousse, ASCR Office (tndousse@er.doe.gov)

Subtopic b References:

1. "Genomics: GTL—Systems Biology for Energy and Environment," U.S. DOE Website, at http://doegenomestolife.org/

2. "Genomics: GTL Roadmap," U.S. DOE Website, at http://doegenomestolife.org/roadmap/index.shtml

c. Computational Methods for Petascale Physics—The Department of Energy supports the development of computational technologies for the recording, processing, storage, distribution, and analysis of very large experimental data sets collected at current or planned High Energy Physics (HEP) facilities [1, 2, 3]. 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 [4] aim to make idle computing resources available to all participating disciplines. The Offices of High Energy physics and Advanced Scientific Computing Office seeks grant applications in support of the design, implementation, and operation of distributed computing systems comprising many distributed Teraflops of CPU power and distributed petabytes of data. Areas of current interest include middleware development for grid-enabled systems, distributed data management and analysis frameworks, distributed system configuration tools, monitoring and accounting tools, and security assurance tools for a distributed environment.

Questions - contact Saul Gonzalez, HEP Office (Saul.Gonzalez@science.doe.gov) or
Thomas Ndousse, ASCR Office (tndousse@er.doe.gov)

Subtopic c References:

1. "High Energy Physics (HEP)," U.S. DOE Office of Science Website, at http://www.science.doe.gov/Program_Offices/HEP.htm

2. "The ATLAS Experiment," CERN Website, at http://atlasinfo.cern.ch

3. "Compact Muon Solenoid," CERN Website, at http://cmsdoc.cern.ch

4. "Open Science Grid," National Science Foundation/U.S.DOE Office of Science Website, at http://opensciencegrid.org

d. Computational Methods for Modeling Subsurface Flow and Transport—The Department of Energy has long-term clean-up and management responsibility for its Cold War era production facilities, and the responsibility for monitoring the behavior of contaminants in the groundwater and vadose zone around existing and future waste disposal and storage areas. Conceptual model development and computer simulation of contaminant transport are important elements of the decision-making process for environmental remediation and monitoring. Simulation of subsurface transport processes on high performance, "leadership class" computers has not been widely utilized by subsurface scientists or environmental managers responsible for remediation decision-making. The intent of this call is to explore what options "leadership class" computing can bring to practical applications of modeling subsurface fluid flow in the context of environmental fate, transport and remediation and to foster

collaborations among subsurface scientists within industry, academia and national laboratories in order to facilitate the use of high performance computers for environmental applications.

Specific areas of potential interest include:

- Incorporation of methods of model abstraction, parameter sensitivity and uncertainty analyses into computer simulations of subsurface transport.
- Methods exploring optimal conceptual and computational model complexity for subsurface transport simulation.
- Development of robust methodologies for the joint inversion of geophysical, hydrological, and biogeochemical data.
- Computational methods examining the scalability ("upscaling"), spatial variability and temporal variability of geochemical and biologically mediated reactions occurring at the molecular level to the field scale.
- Computational methods exploring efficient means of solving very large systems of nonlinear equations, inherent in subsurface transport modeling, on high performance computers.
- Development of parallel programming and output visualization tools enabling subsurface scientists to more easily access and utilize the high performance computing assets within DOE.
- Incorporation of process modeling capabilities into system-modeling tools for the design, analysis, and optimization of complex engineering projects.
- Development of advanced mesh generation and adaptive gridding techniques for the accurate representation of complex hydrostratigraphy, multiscale heterogeneity, and advancing saturation and reaction fronts.
- Development of robust and efficient strategies for the coupling of disparate processes with different inherent time constants.

Questions – contact David Lesmes, BER Office (David.Lesmes@science.doe.gov) or
Thomas Ndousse, ASCR Office (tndousse@er.doe.gov)

Subtopic d References:

1. Steefel, C. I., et al., "Reactive Transport Modeling: Essential Tool and a New Research Approach for the Earth Sciences," *Earth and Planetary Sciences Letters*, 240: 539-558, December 2005. (ISSN: 0022-3530 print) (Abstract and ordering information available at: http://www.elsevier.com/wps/find/journaldescription.cws_home/503328/description#description)

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41:W11425, November 2005. (doi:10.1029/2005WR004237) (ISSN: 00431397) (Full text available from American Geophysical Union. See: http://www.agu.org/pubs/crossref/2005/2005WR004237.shtml)

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PROGRAM AREA OVERVIEW
ADVANCED SCIENTIFIC COMPUTING RESEARCH

The primary mission of the Advanced Scientific Computing Research (ASCR) program is to discover, develop, and deploy computational science and high-performance networking tools and services that enable researchers in scientific disciplines to analyze, model, simulate, and predict complex phenomena important to the Department of Energy. To accomplish this mission, ASCR funds research at public and private institutions and at DOE laboratories to foster and support fundamental research in applied mathematics, computer science, and high-performance network research. In addition, ASCR supports multidisciplinary science activities under a computational science partnership program involving technical programs within the Office of Science and throughout the Department.

ASCR also operates high-performance computing (HPC) centers and related facilities, and maintains a high-speed network infrastructure to support computational science research activities. The HPC

facilities include the National Leadership Computing Facility (NLCF) at Oak Ridge National Laboratory (ORNL), the National Leadership Computing Facility (NLCF) at Argonne National Laboratory, and the National Energy Research Scientific Computing Center (NERSC) at Lawrence Berkeley National Laboratory (LBNL). The high-performance network facilities include ESnet, a 10/20 Gbps high-performance production network at LBNL, and UltraScience Net, a 20 Gbps experimental hybrid optical network at ORNL, used for prototyping, deploying, and testing advanced optical network technologies.

ASCR is interested in receiving SBIR and STTR grant applications on applied computational sciences in the following areas:

- **Applied and Computational Mathematics** - to develop the mathematical algorithms, tools, and libraries to model complex physical and biological systems.

- **High-performance Computing Science** - to develop scalable systems software and programming models, and to enable computational scientists to effectively utilize petascale computers to advance science in areas important to the DOE mission.

- **Distributed Network Environment** - to develop integrated software tools and advanced network services to enable large-scale scientific collaboration and make effective use of distributed computing and science facilities in support of the DOE science mission.

- **Applied Computational Sciences Partnership** - to achieve breakthroughs in scientific advances via computer simulation technologies that are impossible without interdisciplinary effort.

For additional information regarding the Office of Advanced Scientific Computing Research priorities, click here.

36. NUMERICAL SOFTWARE MAINTENANCE

The Office of Advanced Scientific Computing Research has been fully or partially responsible for funding the research and development (R&D) of a wide range of robust, high-quality numerical algorithms for scientific computation. These include the development of libraries such as EISPACK, LINPACK, LAPACK, ScaLAPACK, ARPACK, CLAWPACK, PETSc, TAO, CHOMBO, ebCHOMBO, SALSA, MPSALSA, LOCA, HYPRE, SuperLU, FronTier, and many others. However, a number of critical issues must still be resolved in order to ensure that the value of the software is maintained and that the large R&D investment is maximized.

a. Numerical Software Maintenance, Versioning, and Distribution—Grant applications are sought for the development of technologies to provide: enhanced user interfaces; distribution support; maintenance activities such as collecting and tracking bug reports, and fixing bugs; and portability across platforms (including porting to new computational architectures). Grant applications are also sought to: (1) develop new maintenance and distribution mechanisms to ensure that updated scientific libraries are subjected to validation and verification testing; (2) implement formal tracking mechanisms for bug reports, bug fixes, and update notification for a wide range of scientific algorithm libraries; (3) develop and maintain mechanisms for providing cost effective portability of scientific libraries across a

wide range of computer architectures, from desktop systems to massively parallel leadership-class supercomputers; (4) develop and maintain high-quality user documentation for each component of scientific software, including advice on domains of applicability for each module; and (5) develop comprehensive email- or Web-based user support services for scientific libraries.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

b. Scaling Mathematical Tools and Libraries to Petascale—The DOE Office of Science has entered into the era of petascale computer science – marked by computers that operate a 1000 times faster than today's teraflop computers. Petascale computing will enable the production of scientific simulation data about complex natural phenomena, on a scale not possible just a few years ago. Critical issues that must be resolved to enable science at the petascale computing is scaling existing mathematical libraries and tools to take full advantage of the petascale computing. Grant applications are sought from investigators that will collaborate with domain scientists to scale existing mathematical libraries, solvers, and tools to work efficiently in petascale computers at the National Leadership Facilities at Oak Ridge National Laboratory, Argonne National Laboratory, and National Energy Research Scientific Computing Center.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

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37. SCIENTIFIC VISUALIZATION AND DATA UNDERSTANDING

Scientific visualization and data management are critical enabling technologies for computational science research, which provide scientists with the capability to extract the scientific insights from data sets generated by simulations and experiments. The visualization systems that are sought must be attuned to the needs of domain scientists and be integrated with important data management and domain-specific science. In addition, to be part of a useful investigatory scientific research environment, visualization systems and data analytics must further be integrated with supporting computational science technologies such as petascale computing, data management and storage/retrieval; I/O capabilities, and networking capabilities for remote visualization.

a. Scientific Visualization and Management—Scientific discoveries enabled by petascale computational sciences require advanced visualization systems to extract the scientific insights from data generated by simulation and experiments. With petascale computing and other experiments expected to generate several petabyte of unstructured multi-dimensional data sets per year, next-generation scientific visualization systems will outstrip the performance of today's systems. Next-generation data analytics will be needed to: 1) compare data between different simulation runs, 2) perform statistical analysis on data, 3) perform comparison between simulation data and experimental data, and 4) accommodate uncertainties in data. Grant applications in this subtopic should focus on, but are not limited to: 1) parallel visualization tools and services, 2) tools to enable knowledge discovery at petascale, 3) GPU programming model to multi-GPU systems, 4) high-level I/O libraries optimized for large-scale scientific visualization, 5) full-feature visualization tools for unstructured data, and 6) uncertainty management in scientific visualization.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

b. Petabyte-Scale Data Transformation, Discovery, and Distribution—Science is increasingly becoming more and more data-intensive. In many large-scale scientific experiments and simulations, the data challenge already exceeds the compute-challenge in its needed resources. The scientific importance of storing, discovering, and distributing scientific data on an unprecedented scale to scientists in different geographical locations is clear—it is the limiting or enabling factor of scientific discoveries in many large-scale data-intensive science involving distributed resources and research teams. Grant applications are sought to focus on the development of scalable tools to facilitate the transformation, discovery, and distribution of scientific data (unstructured data). These include but are not limited to: 1) high-speed data transfer protocols and services optimized for optical links, 2) salable tools for storage systems coordination and scheduling, 3) metadata and data replication services to support data distribution, and 4) tools to interface data management systems to network and storage systems. Grant applications focusing on commercial database management extension are beyond the scope of this subtopic and will not be peer-reviewed.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

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38. HIGH PERFORMANCE NETWORKS

Advances in high performance network capabilities and distributed systems technologies are making it easier for large geographically dispersed teams to collaborate effectively. However, significant research questions must be addressed if co-laboratories are to achieve their potential, namely, by providing: (1) remote access to terascale computing resources and data archives; (2) remote users with an experience that approaches "being there;" and (3) remote visualization generated by analysis of large data sets and by simulation. Grant applications are sought to develop software tools and services to support coordinated and dynamic resource sharing in areas such as resource discovery, resource access, authentication, authorization to enable resource sharing and scientific collaborations. Grant applications are sought only in the following subtopics:

a. High-Speed Network Provisioning Tools and Services—DOE operates a production high-performance IP-based network called ESnet. ESnet interconnects science facilities, supercomputer centers, and data repositories, and also enables large scientific collaborations. The current ESnet backbone is based on Packet over SONET. In the future, it is anticipated that the ESnet core network will exploit advanced optical network technologies such as GMPLS and MPLS, in order to deliver end-to-end on-demand circuits and bandwidth. Therefore, grant applications are sought to develop advanced agile optical networks for ESnet. These end-to-end system level technologies must be suitable for deployment and testing on the Ultra-Science Net (USnet), a DOE-funded optical network testbed operated by Oak Ridge National Laboratory. (USnet is used to develop, deploy, and test advanced optical network technologies for ESnet; further information on USnet can found at: http://www.csm.ornl.gov/ultranet/.) Specific areas of interest in agile optical networks include, but are not limited to, rs-GMPLS extensions with bandwidth reservation and scheduling, MPLS and rs-GMPLS security, inter-domain rs-GMPLS signaling, hybrid packet/circuit switched technologies, integration QoS, MPLS, and rs-GMPLS, traffic engineering for rs-GMPLS-based networks, and end-to-end network monitoring tools and services. Grant applications must clearly outline how the proposed technology can be deployed and tested on the USnet testbed. Low level optical networks components such as optical cross-connect, optical amplifiers and signal processing, chip design and manufacturing, wireless network technologies, etc., are beyond the scope of this topic. Grant applications that focus on these technologies will be declined without a peer-review.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

b. High-Speed Network Security Systems—Office of Science R&D activities are conducted in an open but secure science environment. In this environment, the security systems deployed to protect cyber attacks must be carefully designed and deployed, so as to not hinder scientific discoveries. Grant applications are sought to develop intelligent and scalable cyber security systems that can operate at speeds up to 10 Gpbs and beyond. The proposed cyber security systems must be fast, highly robust, and transparent to end users. Technologies of interest include, but are not limited to, ultra-high-speed Intrusion Detection Systems (IDS), high-speed firewall systems, authentication systems for rs-GMPLS control Plane, VLANs security, and optical layer security.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

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39. SCALABLE SYSTEM SOFTWARE FOR PETASCALE COMPUTER SYSTEMS

High-performance computing (HPC) research in the Office of Science at the U.S. Department of Energy supports research that contributes to comprehensive, scalable, and robust computing to enable scientific discoveries. The HPC currently supports research and development that focus on petascale computing systems - computers operate 1000 times faster than today's petascale systems. The primary areas of

research include scalable system software, scientific visualization systems, data management tools, programming models, and related issues. Grant applications addressing these issues are sought in the following subtopics:

a. Petascale System Software—Emerging large-scale science endeavors increasingly call for extreme-scale supercomputing systems. These systems, which will exploit tens to hundreds of thousands of processors, will be based on a variety of challenging architectures from distributed memory clusters of unprecedented scale to radically different innovative architectural concepts such as PIMs, FPGAs, and complex memory hierarchies. This requirement can be met by internal parallel I/O subsystems that comprise dedicated I/O nodes, each with processor, memory, and disks. Massively parallel processors (MPPs), encompassing from tens to thousands of processors, are emerging as a major architecture for high-performance computers. The new supercomputing systems will differ greatly in scale and complexity from today's systems, placing new and challenging demands on system software and related supporting hardware subsystems. Grant applications for these proposed system software components and hardware subsystems must address the needs for: 1) optical transceiver development to improve CPU to CPU and CPU to memory bandwidth performance over copper based solutions, 2) operating systems tools and support for the effective management of terascale systems and beyond; and (3) effective tools for feature identification, (4) parallel and network I/O, and 5) scheduler, lightweight communication mechanisms, and queue management tools, 6) FPGA algorithm accelerator development that maximizes the performance of specific algorithms through a direct connection to the network infrastructure.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

b. Petascale File Systems—Global parallel file systems such as GPFS and Lustre are widely used in the Office of Science to manage file systems in its major computer systems with few thousand processors. This subtopic supports the development of file systems that can scale to thousands of processors. This can be achieved by scaling existing file systems or developing new ones. It is well understood that the bandwidth to storage devices is not keeping pace with computational trends and that the gap will continue to widen in the future. A balanced petascale computer with 100,000 processors will require on the order of 1 Terabytes per second (TB/s) bandwidth. In order to efficiently utilize Petascale computing resources to provide breakthrough science, proposals are sought that address the scaling, performance, and/or stability of an existing or new global parallel file system. Grant applications are sought to develop scalable parallel file systems that explore the use of clustered metadata and metadata checksum/mirroring to handle up to one trillion files in a file system; address the scaling, performance, and/or stability of an existing global parallel file system; and to develop I/O disk and client services to bind the global file systems to storage systems and petascale computing systems.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

c. Debugging and Performance Monitoring of Petascale Systems—Current supercomputing systems consisting of thousands of nodes cannot meet the demands of emerging high-performance scientific applications. As a result, a new generation of supercomputing systems consisting of hundreds of thousands of nodes is being proposed. However, these systems are likely to experience far more frequent failures than today's systems, and such failures must be tackled effectively. Coordinated check-pointing is a common technique to deal with failures in petascale computing system. Unlike most

of the existing check-pointing models, the proposed model takes into account failures during check-pointing and recovery, as well as correlated failures. The parallel debugging solution today, Total View, does not work for users above 1,000 tasks, and only works on one near HPC system beyond 1,000 nodes. Debugging of large scale scientific applications with up to 100,000 interdependent parallel tasks requires renewed exploration of alternative approaches to debugging at massive concurrency. Grant applications are sought for relative debugging development which provides a promising new debugging paradigm for large systems and tens of thousands of processes, fixed block disk development to accelerate performance, improve reliability, and make cost improvements.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

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40. HIGH-PERFORMANCE MIDDLEWARE

Advances in high performance network capabilities and distributed systems technologies are making it easier for large geographically dispersed teams to collaborate effectively. However, significant research questions must be addressed if co-laboratories are to achieve their potential, namely, by providing: (1) remote access to terascale computing resources and data archives; (2) remote users with an experience that approaches "being there;" and (3) remote visualization generated by analysis of large data sets and by simulation. Grant applications are sought to develop software tools and services to support coordinated and dynamic resource sharing in areas such as resource discovery, resource access,

authentication, authorization to enable resource sharing and scientific collaborations. **Grant applications are sought only in the following subtopics:**

a. Scientific Data Management and Understanding—Modern science is increasingly becoming a data-intensive activity, with experiments in science areas such as high-energy and nuclear physics, climate modeling, computational biology, and fusion energy estimated to generate petabyte-scale of unstructured domain science data. Given the projected wave of data and information, the importance of managing scientific data and information is recognized as being in the critical path of modern scientific endeavor. Accordingly, grant applications are sought to develop: (1) workflow for unstructured data management technologies to aid the construction and automation of scientific problem-solving processes; (2) meta-data and data description services to describe and track data within and across different communities; (3) efficient data access and query technologies to handle the organization of complex scientific data that is not based on simple relational tables, as used in commercial systems; (4) scalable data storage and distribution services and tools for data transmission over switched optical links, data replication, and data discoveries; (5) high-speed data storage and caching services to deal with high-performance data access, random I/O, and dynamic data storage and caching; and (6) data analysis services to enable next-generation scientific visualization, feature identification, and tracking. Commercial database systems and their variants dealing with structured data are beyond the scope of the subtopics and will be rejected without peer-review.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

b. Scalable I/O Sub-Systems for Petascale Data Distribution—Moving data into and out of petascale systems quickly is critical to achieving high performance. At the petascale, this involves many hundreds to thousands of I/O channels from the compute nodes, connected by a high speed switch fabric, to file servers. Although switch performance is evolving rapidly, high performance communications switches are not yet optimized for the kinds of loads that petascale computers place on them. In petascale applications, each switch port has a very high duty cycle (so non-blocking architectures are preferred). Also, the data flow is very directional, i.e., a set of ports "A" is always exchanging data with a disjoint set "B", and the "A" ports don't exchange data with other "A" ports. Traffic management is also a problem at the petascale. For example, there are typically more ("A") ports connected to the compute nodes than to file servers ("B" ports), so when data is being dumped from the petaflops system to files, it backs up on the input side of the switch. This must result in even throttling of throughput under high aggregate input load, another condition that varies from the usual application of these switches. In summary, there is a great need for switch hardware and software optimization for petascale applications.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

c. Scalable and Secure Services for Large-Scale Scientific Collaborations Scalable Middleware Technologies—Grant applications are sought for the development and maintenance of scalable middleware technologies that will (1) enable universal, ubiquitous, easy access to remote computing resources and scientific instruments; (2) facilitate collaboration among distributed science teams; and (3) enable a new generation of distributed high-end applications of interest to the DOE. The current interest in this area include but are not limited to 1) long-term enhancement and maintenance of Access Grid facilities and grid software, 2) scalable scientific workflow for large-scale science projects, 3) scalable authentication/authorization services, 4) deployable LAN and WAN QoS services, 5) wide-area

distributed data management, 6) efficient multicast capabilities, 7) automatic resource discovery protocols, 8) remote data access services, and 9) network-attached memory and storage systems.

Questions – contact Thomas Ndousse-Fetter (tndousse@science.doe.gov)

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PROGRAM AREA OVERVIEW
OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION

The primary mission of the Office of Scientific and Technical Information (OSTI) is to advance science and sustain technological creativity by making R&D findings available and useful to DOE researchers and the American public. OSTI's strategy is to accelerate science knowledge diffusion by utilizing innovative tools and resources to speed and ease search of R&D results and related educational resources. To accomplish this mission OSTI uses the results of applied research in advanced scientific search algorithms and related technologies, and operates server, networking, and related facilities. The applied algorithm research efforts provide the mathematical methods to enable scientists to search and rank large numbers of distributed scientific information collections via a single query.

For additional information regarding the Office of Scientific and Technical Information, click here.

41. DISCOVERY, SEARCH, AND COMMUNICATION OF TEXTUAL KNOWLEDGE RESOURCES 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 digitized text formats (journal articles, gray literature research results, e-prints of research results, science project descriptions, and science program descriptions) hosted on geographically dispersed servers. Researchers would benefit greatly if they had ways to simultaneously search across these vast resources and find the specific knowledge they need. While technology has significantly accelerated the availability and quantity of scientific information on the Web, the tools and capabilities to find and search that information have not kept pace. This lag in search technology has created a chasm in the capability to globally search the Internet, especially with regard to distributed scientific textual databases.

Therefore, this topic seeks the discovery of knowledge resources and the creation of user-friendly metasearch tools. Metasearch tools to be built for researchers by organizations like the Office of Scientific and Technology Information (OSTI) require identification of textual knowledge databases that researcher's need, together with appropriate configuration files to access them. Such metasearch tools must enable researchers to quickly search such databases and must present the search results in researcher-friendly ways. Such researcher-friendly ways to present search results include precision searching (e.g., relevance ranking), clustering, etc.

a. Discovering and Utilizing Knowledge Sources for Metasearch Knowledge Systems—To enable metasearch systems to be created and deployed, grant applications are sought to develop scalable concepts and technologies for discovering and utilizing authoritative, foreign and domestic, distributed collections of textual information in databases and web pages, with emphasis on the scientific disciplines of interest to DOE. Such textual information often contains tables, graphs, illustrations, photographs, etc. Grant applications are sought to develop the ability to search within the text for the titles, legends, headings, and data within these supplemental pieces of information and/or other subparts of documents. Examples of textual collections include; R&D results such as conference proceedings, gray literature, journal articles, and e-prints; R&D Project descriptions; R&D Program descriptions; and patents. OSTI's content can be made available to grantees as a source of information to drive and test the concepts and technologies used to discover and utilize authoritative information. Grant applications are sought for technologies to automatically configure or partially configure middleware to discover new sources, or otherwise make knowledge sources accessible via metasearch. If a grant application envisions the modification of an existing knowledge source, the application must document an appropriate agreement with the owner of such source.

Questions – contact Walter Warnick (walter.warnick@science.doe.gov)

b. Researcher-friendly Presentation of Metasearch Results—Grant applications are sought to develop scalable concepts and technologies for presenting metasearch results quickly in researcher-friendly ways. Such researcher friendly ways to present search results include precision searching (e.g., relevance ranking), clustering, and/or other ways proposed by the applicant. As scaling to many hundreds of database sources is envisioned, speed of response to the information researcher customer is an important metric.

Questions – contact Walter Warnick (walter.warnick@science.doe.gov)

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5. "GrayLit Network," U.S. DOE OSTI Website. (URL: http://www.osti.gov/graylit)

6. "Federal R&D Project Summaries," U.S. DOE OSTI Website (URL: http://www.osti.gov/fedrnd)

7. "E-Print Network," U.S. DOE OSTI Website. (URL: http://www.osti.gov/eprints)

PROGRAM AREA OVERVIEW
OFFICE OF DEFENSE NUCLEAR NONPROLIFERATION

The Office of Defense Nuclear Nonproliferation is the organization within the Department of Energy's National Nuclear Security Administration (NNSA) responsible for preventing the spread of materials, technology, and expertise relating to weapons of mass destruction; and for eliminating inventories of surplus fissile material. Specifically the organization: Secures nuclear materials, nuclear weapons, and radiological materials at potentially vulnerable sites in Russia and elsewhere; Reduces quantities of nuclear and radiological materials; Bolsters border security overseas; Strengthens international nonproliferation and export control regimes; Downsizes the nuclear weapons infrastructure of the former Soviet Union (FSU); Mitigates risks at nuclear facilities worldwide and Conducts cutting-edge nonproliferation and national security research and development (R&D).

The following topics focus on nonproliferation research and development opportunities. The Office of Nonproliferation Research and Development conducts applied research and development, testing, and evaluation to produce technologies that lead to prototype demonstrations and resultant detection systems, strengthening the U.S. response to current and projected threats to national security worldwide posed by the proliferation of weapons of mass destruction (WMD) and the diversion of special nuclear material. DOE's NNSA is the only U.S. government agency investing in long-term strategic and often high-risk technical solutions to detect the proliferation of WMD. The R&D program is the technical base that provides operational agencies, including the Department of Defense (DOD) and the intelligence community, with innovative systems and technologies to meet their nonproliferation, counter-proliferation, and counter-terrorism responsibilities.

The Office develops applicable technologies, demonstrates and validates fieldable prototypes and, in the treaty monitoring area, provides actual operational hardware and software. The Office's work is focused in two programmatic areas: proliferation detection and nuclear explosion monitoring.

For additional information regarding the Office of Nonproliferation Research and Development priorities, click here.

42. RESEARCH TO SUPPORT PROLIFERATION DETECTION

The Proliferation Detection Program (PDP) applies the unique skills and capabilities of the NNSA and the DOE national laboratories and facilities to close nonproliferation technology gaps, identified through close interaction with other U.S. government agencies and in support of U.S. government policy. PDP develops the tools, technologies, techniques, and expertise to address the most challenging problems related to the detection, localization, and analysis of the global proliferation of weapons of mass destruction, with special emphasis on nuclear weapons technology and the diversion of special nuclear materials. In addition, PDP funds research that supports counter-proliferation and counter-terrorism missions, where there is synergy with the nonproliferation mission.

PDP facilitates long-term scientific innovation through sustained commitment to mission focused technical areas that build "best-in-the-world" competence. PDP also plays a key role in filling the critical middle ground between fundamental research and near-term acquisition, by using the unique skills of the national laboratories and plants as applied research integrators. Through the extensive relationships that the laboratories maintain with universities, basic science from academia and federal research programs are brought together to develop real-world system solutions based on classified insights into national security problems. PDP hands off technical know-how, which has been developed and validated, to U.S. Government acquisition programs and the U.S. industrial base to support national security missions. Technical advances, new proven methodologies, and improvements to capabilities are transferred to operational programs through technical partnerships; partnerships with industrial suppliers are often coordinated with user programs to facilitate successful outcomes. **Grant applications are sought only in the following subtopics:**

a. Spectroscopic Quality Radiation Detection Materials Growth—The Advanced Materials program in the Office of Nonproliferation R&D supports the radiation detection program in NNSA and searches for advanced concepts to develop new radiation detection materials. The program is currently focused on the development of improved capabilities for both scintillator and semiconductor based radiation detectors; i.e. the development of a systematic search for new radiation detection materials, the development of better methods to characterize radiation detection materials, and the development of improved techniques that enhance the growth or fabrication of radiation detection materials. The objective of the program is to gain insight into a mechanistic understanding of material performance as the base component of radiation detectors. The program is interested in moving beyond the largely empirical approach of finding and understanding detector materials.

In this subtopic, we are interested in promoting the industrial capacity to develop large volume, high quality radiation detector materials. Recent research has shown paths to development of CZT (Cd-Zn-

Te) crystals that are of excellent spectroscopic quality, showing bulk energy resolution of <1% (FWHM). This level of performance has the capability of enabling detection scenarios requiring reliable radioisotope identification with room temperature materials.
Grant applications are sought to improve growth issues involving this material so that reliable, high yield, rapid, and large volume growth of CZT is readily achievable. Successful Phase I awardees should describe a clear path to improving upon existing growth techniques to produce large CZT crystals (up to and exceeding 10 cm^3) of spectroscopic quality (at or less than 1% FWHM at 0.662 MeV), at high yield, such that a factor of 10 cost reduction over current fabrication costs are realized. Phase II will require the demonstration of material fabrication with the above mentioned characteristics and that are free from dislocations, cracking, chemical heterogeneities, and minor crystalline phase impurities including precipitates.

b. Radiation Detector Development from Emerging Advanced Materials—The Office of Nuclear Nonproliferation Research and Development is focused on enabling the development of next generation technical capabilities for radiation detection in the nuclear nonproliferation arena. As such, grant applications are sought for the development of radiation detection techniques and sensors that address the pressing national need to enhance the capability for 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, resent research and development has resulted in the emergence of radiation detection materials that have high-energy resolution. Grant applications are also sought to develop radiation detectors from these materials that are rugged, reliable, low power, and are capable of high confidence radioisotope identification.

The office of nonproliferation research and development sponsors the development of detectors, sensors, and other enabling technology to enhance radiation sensing and detection for nonproliferation applications as outlined above. Basic and applied research for the transition of advanced detector materials to functional, robust radiation detectors is critical to the development of such enabling technology. This subtopic focuses on the research and development needed for industrial scale production of large volume and high quality radiation detectors from the semiconductor material Cadmium Zinc Telluride (CZT) with the ultimate goal of producing radiation detectors with volumes in the 10's to 100's of cm^3 with energy resolution of less than 1% FWHM at the 0.662 MeV. Areas of interest include: 1) the development of reliable electrical contacts to this semiconductor detector material which requires the understanding of the relevant surface physics/chemistry; 2) the development of low-power, low-noise electronics for detector read out (i.e. ASICS with less than 2 eV noise and less than 1mW per detector channel power consumption); 3) engineering solutions for the rugged mounting of the detector crystal to withstand high mechanical and thermal shock; 4) the development of unique detector readout schemes; and 5) any other research leading to the production of high quality radiation detectors from these materials with particular emphasis on the development of industrial scale production techniques.

c. Technique for Fabricating Optical Quality Gradient Index Spheres—Grant applications are sought for the development of a method for fabricating millimeter scale spheres having an optical index that varies smoothly and continuously from the center to its radius. The fabrication procedure must be flexible enough to allow the creation of a range of index profiles. The spheres are to be optically transparent and have a refractive index differential greater than 0.2. The materials from which the lens is fabricated can be either organic or inorganic and the fabrication technique must be capable of scaling to

low cost multiple copy production. The optical quality of the final product must be capable of providing near diffraction limited performance.

d. Compression of Registered Wide-Area High-Resolution Aerial Video—Grant applications are sought to develop image-sequence compression methods that support a transmit-to-ground capability for aerial imagery consisting of fifty to over a billion pixels per frame, acquired at several frames per second. Imagery is assumed to be registered per pixel to a fixed ground position with sub-pixel accuracy with respect to the image plane, and to the accuracy of 90-meter global SRTM (Shuttle Radar Topography Mission) data in the depth direction. Typically, such imagery consists of mostly static background, plus moving objects (such as cars) and high-frequency background motion (such as water or leaf shimmer). It is important for downstream applications to get very accurate background imagery at low time frequency, and very accurate space and time resolution of all potential moving objects. High-frequency background regions do not require high accuracy, but can be summarized statistically at low bit rates. Overall the compression rates required are 1000:1 to 10,000:1 relative to the raw 8-12 bit grayscale imagery in order to match available wireless communications bandwidth. Grant applications may assume that fast, approximate mover detection algorithms are available.

References:

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43. RESEARCH TO SUPPORT NUCLEAR EXPLOSION MONITORING

The Nuclear Explosion Monitoring Research & Engineering (NEM R&E) program is sponsored by the U.S. Department of Energy's (DOE) National Nuclear Security Administration's (NNSA) Office of Nonproliferation Research and Development (NA-22). This program is responsible for the research and development necessary to provide the U.S. Government with capabilities for monitoring nuclear explosions. The NEM R&E program provides research products to the Air Force Technical Applications Center (AFTAC), which collects and analyzes data from a network of Ground-based seismic, radionuclide, hydroacoustic, and infrasound data collection stations and satellite systems. 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. Grant applications responding to this topic must demonstrate how the proposed approaches would complement and be coordinated with ongoing or completed work (see list of ongoing contracts https://www.nemre.nnsa.doe.gov/coordination**)** while improving capability. In addition, grant applications should address the manufacturability of any instruments or components developed. Grant

applications must be specifically related to nuclear explosion monitoring and **must respond only to the following subtopics:**

a. Seismic Monitoring of Nuclear Explosions—Grant applications are sought to develop the next generation of low-noise, high-quality seismometers. It is envisioned that these seismometers will be intrinsically digital, eliminating electrical noise involved with analog cables and circuitry. A transducer should directly sense the position of the seismometer mass in a digital format to a high precision (at least 0.005 nanometer/count at 1 Hz). Sensor noise should be at least 10 dB below the USGS New Low Earth Noise Model and dynamic range at least 134 dB over a frequency band of 0.02 to 16 Hz. A force-feedback configuration may be considered to reduce noise and increase dynamic range. Ideally, size and power consumption should be reduced relative to a traditional seismometer/digitizer combination. Integration of additional system functions (communications, control, data storage, timing) into the digital seismometer should be considered. All communications with the sensor should be in a common digital format.

b. Radionuclide Monitoring of Nuclear Explosions—Grant applications are sought to investigate low cost improvements in the use of lower resolution detectors such as NaI and CsI for the detection of radioactive debris from a nuclear explosion, using spectral resolution enhancement or spectral deconvolution techniques. Techniques are sought based on spectral denoising and filtering, Gaussian parameterization, Monte Carlo radiation transport derived detector response functions, and novel multi-sweep processing schemes to synthetically enhance the resolution of a characteristically poor resolution spectra collected at room temperature from a sodium iodide NaI and CsI detector-photomultiplier systems. Methods are sought that can synthetically extract photopeak doublets from unresolved, low resolution peaks possessing varying levels of skewness and kurtosis. Software algorithms are sought that can rapidly process the collected spectrum and synthetically render photo-peaks, which can be linked to nuclide identification software.

c. Space-based Monitoring of Nuclear Explosions—Grant applications are sought to investigate space environment qualified and radiation tolerant optics for mid-range IR (5-14 μm). Total integrated dose > 100 krad. Transmission during the life of the glass should be above 65%. Fiber optic transceivers that function at 850 nm that are space environment qualified with a SEU of greater then 20 MeV/mg-cm^2 and a total integrated dose > 100 krad.

d. Development of COTS-In-Space Reconfigurable Processing Architectures—The Department of Energy's National Nuclear Security Administration, Office of Nuclear Nonproliferation Research and Development has a large and continuing effort in space based remote sensing. It is now commonly observed that Remote Sensing drives sensor data rates far in excess of what is possible to economically down link from a satellite, let alone process on the ground. This in turn leads to a strong desire for better methods for on-orbit processing of signals and images, which is the focus of this research subtopic.

Experience has shown that if commercial off the shelf (COTS) computing devices can be used in space, then large gains in Operations/watt performance can be had, enabling on-orbit processing of remote sensing data. However there are large gaps between COTS radiation and thermal capabilities, and what is needed for reliable operation in various space environments. Grant applications are sought to address this gap with a comprehensive testing plan and testing program, designed to migrate new COTS parts

into LEO, GEO, MEO, or interplanetary environments, in increasing order of difficulty. Successful applications will further plan to integrate said parts into new processor prototype designs within Phase II.

Extensive and deep collaboration with the Office of Nuclear Nonproliferation Research and Development (NA-22) laboratories, and 3rd party U.S. Government FFRDC, laboratories, and partner entities, will ultimately be required for successful implementation of the technology. Grant applications with previous documented experience with COTS-in-Space development, together with novelty of work, and ability to collaborate in an existing team of FFRDC, will be the preferred applications.

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1. "Nuclear Explosion Monitoring Research and Engineering Program Strategic Plan," National Nuclear Security Administration, September 2003. (Document No. DOE/NNSA/NA-22-NEMRE-2003) (Full text available at https://www.nemre.nnsa.doe.gov/cgi-bin/prod/nemre/index.cgi?Page=Strategic+Plan)

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

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4. "Proceedings of the 25th Seismic Research Review-Nuclear Explosion Monitoring: Building the Knowledge Base," Tucson, AZ, September 23-25, 2003, sponsored by National Nuclear Security Administration/Air Force Research Laboratory; Los Alamos National Laboratory, 2003. (Report No. LA-UR-03-6029) (Available at: https://www.nemre.nnsa.doe.gov/cgi-bin/prod/srr/index.cgi)

5. "Proceedings of the 24th Seismic Research Review—Nuclear Explosion Monitoring: Innovation and Integration," Ponte Vedra Beach, FL, September 17-19, 2002, sponsored by National Nuclear Security Administration/Defense Threat Reduction Agency; Los Alamos National Laboratory, 2002. (Report No. LA-UR-02-5048) (Available at https://www.nemre.nnsa.doe.gov/cgi-bin/prod/srr/index.cgi)

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8. "Publications Relating to Radiation Effects [and Static Random Access Memory Field Programmable Gate Arrays (SRAM FPGAs)]," Los Alamos National Laboratory Reconfigurable and Adaptive Systems Research Webpage. (Publication list available at: http://www.rasr.lanl.gov/RadEffects/publications.php)

PROGRAM AREA OVERVIEW
OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

The mission of the Office of Electricity Delivery and Energy Reliability (OE) is to lead a national effort to modernize and expand America's electricity delivery system in order to ensure a more reliable and robust electricity supply. This will be accomplished by actions that eliminate bottlenecks, foster competitive electricity markets, and expand technology choices. A modernized grid will significantly improve the Nation's electric reliability, efficiency, and affordability, and contribute to economic and national security. The risk of multi-regional blackouts will be reduced through better visualization and controls of the electric grid, superconductivity for electric systems, advanced cable design, storage and power electronics, use of distributed energy resources and micro-grids, as well as other technologies supported by the Office. Effective application of all these technologies requires development of less expensive high temperature superconducting second generation wire, advanced materials for power electronics and energy storage, modeling and analysis.

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

44. HIGH TEMPERATURE SUPERCONDUCTING (HTS) SECOND GENERATION WIRE

Substantial worldwide advances have been achieved in recent years with respect to the development and processing of second generation, high temperature superconducting coated conductors (also known as "2G wires"). Compared to first generation wires, these coated conductors have the potential of providing lower cost and higher performance. These wires also provide the possibility of operation at moderate magnetic fields in liquid nitrogen as well as high fields at lower than liquid nitrogen temperature. For short laboratory-scale samples, very high current carrying capacities over 1,000 A/cm at 77K have been reported. Pre-commercial coated conductors, longer than 300 meters and with current-carrying capacity over 200 A/cm, also have been demonstrated. Nonetheless, further innovation and development will be needed to achieve the DOE vision for commercial availability of 2G wires that have a cost/performance ratio as low as $10/kA-m (dollars per kiloampere-meter) and can be fabricated in practical forms. **Grant applications are sought only in the following subtopics:**

a. Effect of Filament Geometry on AC Loss—For practical ac applications, ac loss from 2G conductor remains a concern. Although superconductor filamentization has been shown to be a proven method of AC loss reduction in low temperature superconducting and first generation high temperature superconducting wires, present 2G wires instead consist of a continuous layer of Rare-Earth$_1$Ba$_2$Cu$_3$O$_x$ superconductor. In addition, the current-stabilizer layer, which is in direct contact with the superconductor, is also continuous. It would be advantageous to establish how various filament shapes, arrangements, and geometries affect the AC loss of 2G conductors. Therefore, grant applications are

sought to determine the influence of superconductor filament shape, arrangement, and/or geometry on AC loss using potentially scaleable filamentization methods. Approaches of interest include: (1) detailed studies of reduced-loss coated conductor designs, including hysteretic, coupling, eddy current and transport losses projected over broad ranges of frequencies and field-sweep amplitudes; and (2) the development of scalable, cost-effective continuous methods to filamentize the superconducting and stabilizing layers.

Questions – contact Harbans Chhabra (harbans.chhabra@hq.doe.gov)

b. Low Aspect-Ratio Coated Conductors—Traditional superconducting wires are typically round or of low aspect-ratio. On the other hand, present 2G tapes are of high aspect-ratio, a geometry does not lend itself to twisting, which is a proven way to reduce AC loss. In addition, for wide tapes, gaps can result during winding, which further increases loss. Therefore, grant applications are sought to develop innovative approaches to obtain low aspect-ratio conductors using present 2G tapes, or to develop low-cost templates that are of natural low aspect-ratio. Approaches of interest include: (1) innovations for the scalable fabrication of low aspect-ratio or round-wires using present 2G tapes; (2) the determination of the characteristics of such wires, including transport, AC loss, and mechanical and tape-to-tape interaction; and (3) novel substrate fabrication methods that can result in low aspect-ratio or rounded templates.

Questions – contact Harbans Chhabra (harbans.chhabra@hq.doe.gov)

c. Cryogenic Dielectric Materials that can be Integrated into 2G Conductors—The lack of appropriate cryogenic dielectric materials is one of the barriers to the commercial application of superconductors. For 2G conductors, wrapping with dielectric tapes is a costly, time consuming, and potentially conductor-damaging approach. Grant applications are sought to identify and develop high-performance, cryogenic dielectric materials, and to develop low-cost scalable methods to integrate such dielectrics into the 2G conductor architecture as coatings. Approaches of interest include: (1) the identification and characterization (with respect to dielectric strength, partial discharge behavior, mechanical and thermal compatibility, under cryogenic conditions) of existing high performance dielectric materials that can potentially be integrated into 2G conductors by scalable methods; and (2) the development of novel dielectrics with enhanced cryogenic performance.

Questions – contact Harbans Chhabra (harbans.chhabra@hq.doe.gov)

d. Novel Ultra-Fast Techniques to Deposit Epitaxial Layers for Low-Cost 2G Conductors—One of the major factors that inhibits rapid throughput, and hence increases the cost, of 2G conductors is the moderate deposition rate of buffers and high temperature superconducting films. Thus far, the approach has been to increase the deposition area using moderately-rapid deposition techniques. Grant applications are sought to develop methods for ultra-fast deposition rates (for example, greater than 10 nanometers per second) for the production of highly textured epitaxial films (buffers and/or superconductor). By the end of Phase II, the proposed research project should demonstrate not only ultra-fast deposition but also that the deposited buffer or superconductor is capable of sustaining high current density.

Questions – contact Harbans Chhabra (harbans.chhabra@hq.doe.gov)

References:

1. Ashworth, S. P. and Grilli, F., "A Strategy for the Reduction of AC Losses in YBCO Coated Conductors," *Superconductor Science and Technology*, 19(2): 227-232, February 2006. (ISSN: 0953-2048) (Abstract and ordering information available at: http://www.iop.org/EJ/journal/SUST. Scroll to bottom of page to search for article.)

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45. POWER ELECTRONICS AND ADVANCED MATERIALS FOR ENERGY STORAGE

Low cost, reliable, power control and storage technologies are needed to handle increasing levels of power flow in distribution and sub-transmission applications. Local voltage regulation and the supply of operational reserves from Distributed Energy Resources are being planned by major transmission operators. These power control and storage technologies are essential for optimizing overall transmission reliability and maximizing existing transmission flow capacity. The use of local resources

is becoming increasingly accepted in many regions, but the reliability, cost and lifetime of power electronic equipment has been lagging behind the need. Power electronic interfaces are needed for Distributed Energy applications that can be more flexible, carry higher power levels, and solve existing control problems. Electrical energy storage devices have the potential to increase their capabilities through the use of custom engineered materials in the storage element. Specific items of interest for improvement are the energy storage density, cycle lifetime, and reliability of these devices. The desired end state of this topic is the significant improvement of distributed energy systems ability to meet the needs of the modern day grid.

Grant proposals are being sought in the following areas:

a. Wide Band Gap, High Voltage, High Frequency Switches—Semiconductor switches play a vital role in power conversion. System cost, performance, efficiency, reliability, speed and footprint are all dependent on the performance of switches. Power conversion systems are essential in the transmission and distribution system for incorporation of devices such as FACTS controllers, energy storage, and DER systems needed to increase electric grid reliability. Wide-band-gap materials such as silicon carbide (SiC) are being developed rapidly and are being proposed for use in higher performance switches. Potential improvements over existing, commercial silicon-based switches (e.g., Si-based thyristor and GTO switches) include higher operating voltages, higher operating frequencies, increased efficiency, lower losses and higher operating temperatures. Grant applications are sought to develop advanced SiC-based, or wide band gap MOSFET, high power switches that provide greater than 6kV breakdown voltage and 1kA operating current. The Phase I project should demonstrate the feasibility of such switches to advance the current state of development. Potential follow on projects would include improvement and testing of these devices, and the inclusion of these devices into a power conversion system for high power application.

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

Subtopic a References:

1. Schmit, A., et al., "Development of a Current Scaleable Emitter Turn-off Thyristor Module," Proceedings of APEC 2005: Twentieth Annual IEEE Applied Power Electronics Conference and Exposition, Austin, TX, March 6-10, 2005, 3: 2009-2013, March 2005. (Brief summary available at: http://ieeexplore.ieee.org/Xplore/login.jsp?url=/ie15/9847/31031/01453334.pdf?tp=&arnumber=1453334&isnumber=31031).

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b. Reactive Power Supply—Conventional Distributed Energy (DE) inverters (used in fuel cells, microturbines, etc.) generally operate in one of two modes: voltage source or current source. In the voltage source mode, the inverter supplies a regulated voltage to satisfy a local voltage schedule determined with the distribution utility and the load determines how much current is drawn – a low impedance load draws more current. Conversely, in the current source mode, the inverter does not regulate voltage, but regulates the supply of current. When microturbines are connected to an electricity grid, they normally are operated in the current source mode; i.e., the inverter regulates the amount of current (and thus power) supplied, and the microturbines are dependent on the grid for the regulation of voltage. However, when inverters are used in voltage regulation applications, and at the same time are required to supply power from a microturbine, they will have to regulate both voltage and current (power) at the same time. Grant applications are sought to design and build an inverter control circuit for a conventional DE inverter that will regulate voltage and power simultaneously. The research project should culminate with the demonstration of a prototype capable of providing 25 kW at 480 volts, while regulating voltage using an output power factor with a range of 0.7 lead/lag. The demonstration should show that the device can be set to provide a dispatched level of power and at the same time regulate its terminal voltage. A control method also should be selected for the device, based upon an evaluation of complexity, reliability, and cost.

Questions – contact Merrill Smith (merrill.smith@hq.doe.gov)

Subtopic b References:

1. "Principles for Efficient and Reliable Reactive Power Supply and Consumption," Staff Report, Federal Energy Commission, February 4, 2005. (Docket No. AD05-1-000) (Full text available at: http://www.ferc.gov/eventcalendar/Files/20050310144430-02-04-05-reactive-power.pdf)

2. "A Preliminary Analysis of the Economics of Using Distributed Energy as a Source of Reactive Power Supply," prepared for the U.S. Department of Energy, April 2006. http://www.ornl.gov/sci/engineering_science_technology/cooling_heating_power/pdf/2006_April_economics_of_dg_for_rp.pdf

3. "Synchronizing on West Point," *Public Utilities Fortnightly*, page 54, "Technology Corridor," February 2006. (Article discusses inverters used in today's adjustable speed drives that can be used to change power factor; the net power factor for West Point could be corrected to near 1.0.) (ISSN: 1074-6099)

c. Advanced Nano-Materials for Energy Storage Applications—Electrochemical energy storage devices (batteries, electrochemical capacitors, etc.) are used in the transmission and distribution systems to provide emergency backup power, improve system stability and to lower demand peaks reducing T&D congestion at critical times. The science-based engineering and tailoring of the materials used in these devices provides a significant opportunity to improve device performance. These improvements include potential increases in energy density, improved rate capability (higher power), reduced corrosion, reduced rate of electrode failure (e.g. through sulfation), and increased lifetime. Grant applications are sought to develop and apply carbon nano-tubes and other nano-engineered materials to improve the performance, reliability, and lifetime, and reduce the costs, of energy storage devices used for a variety of utility applications.

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

Subtopic c References:

1. Che, G., et al., "Carbon Nanotubule Membranes and Possible Applications to Electrochemical Energy Storage and Production," *Nature*, 393(6683): 346-347, May 1998. (First paragraph and ordering information available at: http://www.nature.com/index.html. Search archives.)

2. Yuan, Y. F., et al., "Size and Morphology Effects of Zno Anode Nanomaterials for Zn/Ni Secondary Batteries," *Nanotechnology* 16(6): 803–808, June 2005. (Abstract and ordering information available at: http://www.iop.org/EJ/abstract/0957-4484/16/6/031.)

46. MODELING AND ANALYSIS

The National Energy Modeling System (NEMS) was developed to support energy policy analysis and strategic planning within the Department of Energy (DOE) and the Energy Information Administration (EIA). NEMS has the capability to simulate the effects of various energy policies on U.S. energy supply and demand, including economic, environmental, and national security impacts. However, NEMS does not adequately model the electricity delivery system, and thus, for instance, can not be used to estimate the benefits of upgrading the national transmission grid.

a. Electricity System Reliability Model—Grant applications are sought to develop a model, or an equivalent analytical tool, of the electricity delivery system that can be used to quantitatively assess the economic, environmental, reliability, and security benefits of new technologies – especially those technologies resulting from the research programs of the DOE's Office of Electricity Delivery and Energy Reliability. Grant applications should include a comprehensive research plan, in Phase I comprising the development of the model architecture, identification of data needs and performance metrics, development of early software prototypes, and demonstration of the feasibility of the proposed approach. The Phase II deliverable should result in a fully developed and demonstrated model.

Questions - contact Poonum Agrawal (poonum.agrawal@hq.doe.gov)

References:

1. U.S. DOE Office of Electricity Delivery and Energy Reliability Website (URL: http://www.oe.energy.gov/)

2. "National Electric Delivery Technologies Roadmap," U.S. DOE Office of Electric Transmission and Delivery, January 2004. (Full text available at: http://www.oe.energy.gov/DocumentsandMedia/ER202-9-4.pdf)

3. "Grid 2030: A National Vision for Electricity's Second 100 Years," U.S. DOE Office of Electric Transmission and Delivery, July 2003. (Full text available at: http://www.oe.energy.gov/docs/reports_studies.htm)

4. "Methodology for Estimation Prospective Benefits of Energy R&D Programs," Committee on Prospective Benefits of DOE's Energy Efficiency and Fossil Energy R&D Programs, National Research Council, 2004. (ISBN: NI000576) (Full text available at: http://www.oe.energy.gov/docs/reports_studies.htm)

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PROGRAM AREA OVERVIEW
OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH

The Biological and Environmental Research (BER) Program supports fundamental, peer-reviewed research in climate change, environmental remediation, genomics, systems biology, radiation biology, and medical sciences. BER funds research at public and private research institutions and at DOE laboratories. BER also supports leading edge research facilities used by public and private sector scientists across a range of disciplines: structural biology, DNA sequencing, functional genomics, climate science, the global carbon cycle, and environmental molecular science.

BER has a particular interest in the following areas:

(1) Climate Change research aimed at the development of advanced climate models to describe and predict the roles of oceans, the atmosphere, ice and land masses on climate over time and research to understand how carbon dioxide moves through the environment, ways to increase its removal from the atmosphere, and its impacts on the Earth's climate and ecosystems.

(2) Environmental Remediation research aimed at the development of advanced treatment options for nuclear waste, thereby extending the frontiers of methods for remediation, discovering the fundamental mechanisms of contaminant fate and transport in the environment and developing cutting edge molecular tools for investigating environmental processes will yield science-based strategies to reduce the costs, risks, and time for cleanup of DOE sites contaminated from years of weapons research.

(3) Medical Sciences research aimed at the development of advanced imaging and other medical technologies including highly sensitive radiotracer detectors, radiopharmaceuticals, and new technologies such as an artificial retina that will give vision to the blind.

(4) Life Sciences research aimed at the development of innovative solutions along unconventional paths to solve challenges in energy and the environment. Research is focused on developing a predictive understanding of microbes and microbial communities that will lead to the development of biotechnology solutions for producing biofuels such as cellulosic ethanol or hydrogen, help control greenhouse gases such as carbon dioxide and help clean up environmental contamination. This program also supports genomic DNA sequencing and research to understand the biological effects of low doses of radiation.

For additional information regarding the Office of Biological and Environmental Research priorities, click here.

47. CARBON CYCLE MEASUREMENTS OF THE ATMOSPHERE AND THE BIOSPHERE

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

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

Grant applications submitted to this topic should demonstrate performance characteristics of proposed measurement systems, and show a capability for deployment at field scales ranging from experimental plot size (meters to hectares of land – with comparable dimensions for marine systems) to nominal dimensions of ecosystems (hectares to square kilometers). Research to develop miniaturized sensors to determine atmospheric CO_2 concentration is also encouraged. In addition, Phase I projects must perform feasibility and/or field tests of proposed measurement systems to assure a high degree of reliability and robustness. Combinations of stationary remote and *in situ* approaches will be considered, and priority will be given to ideas/approaches for verifying biosphere carbon changes and for estimating carbon sequestration. Measurements using aircraft or ballon platforms must be explicitly linked to real-time ground-based measurements. Grant applications based on satellite remote sensing platforms are beyond the scope of this topic, and will be declined. **Grant applications are sought only in the following subtopics:**

a. Sensors and Techniques for Measuring Terrestrial Carbon Sinks and Sources—Measurement technology is required to quantify carbon sequestration by natural vegetation and ecosystems (i.e., carbon sinks) as well as CO_2 emissions to the atmosphere from natural or industrial sources. Grant applications are sought to develop sensors and unique measurement techniques (and associated system technology, if appropriate) to detect and quantify annual net carbon changes of terrestrial vegetation for large areas, or to measure and verify the magnitude of CO_2 emissions from various sources. 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, 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 0.5 ppm or less. Mechanical sensors must be durable in the full range of normal environmental conditions and exposures, including exposure to dust, rain, snow, heat, extreme cold, and fog. Operation in unattended, remote locations for weeks at a time, without degradation of the measurement, is also required; however, daily telecommunication with the system for monitoring performance and detecting potential operational problems would be desirable.

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

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

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

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

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

(3) Grant applications are sought to develop instruments for measuring atmospheric CO_2, lightweight (approximately 100 grams) sensors, which are capable of measuring fluctuations of CO_2 in air of the order of plus or minus 1 ppm in a background of 370 ppm. The devices must be suitable for launch on ballonsondes or similar such platforms, and therefore must be insensitive to large changes in ambient

temperature and pressure. The devices also must be able to operate on low power (e.g., 9v battery), and have a response time of less than 30 seconds.

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

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

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

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

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

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

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

b. Improved Technology for Transformation of Plant Cells—The genetic engineering of microbes for beneficial purposes is now routine, with robust technologies available for gene transformation and mutagenesis. For plants, comparable precision engineering capabilities are not yet available; however, these capabilities are essential for enhancing our fundamental understanding of gene function and regulation, especially with respect to production of significant amounts of biofuels. Grant applications are sought to develop innovative methods in plant improvement and biotechnology, in order to: (1) improve the efficiency and fidelity of: chromosomal homologous recombination, chromosomal gene targeting, and high-throughput stable transformation and phenotyping of emerging biomass crops (especially perennial grasses); and (2) introduce and establish new chromosomes carrying desirable gene(s) in plants.

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

c. Microbe-Based Fuel Production—Biotechnology offers the promise of capitalizing on the natural capabilities found in the microbial world to produce new fuels, leading to a reduction in green house gas emissions. In particular, many microbes have the ability to produce hydrogen under particular conditions. Therefore, grant applications are sought to demonstrate and quantify: (1) microbe-based hydrogen production reactors, or (2) high-throughput assays for assessing and quantifying the production of microbe-based hydrogen in experimental reactors.

In addition, a more complete understanding of the enzymes and microbes involved in the conversion of cellulosic material to ethanol could overcome inefficiencies in current production processes. Therefore, grant applications are sought to take advantage of advances in GTL science, as well as in systems biology, to simplify and consolidate the conversion of cellulose to ethanol. Emphasis should be placed on developing process improvements from externally generated, biologically-derived catalysts; single

organisms; and/or integrated microbial systems composed of a stable consortium of organisms. Approaches of interest include improving the pretreatment of lignocellulosic material for saccharification and developing organisms that: (1) thrive in optimal bioreactor temperatures and pH environments; (2) ferment both C5 and C6 sugars; and (3) catalyze products in spite of inhibitors, including high concentrations of ethanol. Proposed approaches should coordinate with the research goals described in the DOE GTL Roadmap [7] and Breaking the Biological Barriers to Cellulosic Ethanol: a joint research agenda [8].

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

d. Informatics—Scientists studying the microbiology of environmental applications need to address a wide variety of data that should be linked to each other and readily accessible to multiple members of a team. These data arise from many sources, both from team members and from the broader research community. Grant applications are sought to develop a user-friendly, visual database interface that can display biological data that is applicable in both a laboratory context (i.e., data describing samples that are tracked by a LIMS-type application) and a biological context (i.e., data that provides inference across organisms). The database interface should be interoperable across different locations. The software should be capable of combining environmental, phenotypic, and genomic data for microbes, along with image and biochemistry data – all keyed where appropriate to geographic data. The phenotypic data should include information such as growth curves and metabolic capabilities; the genomic data should include arrays, proteomics, and metabolomics; the image data should include both *in situ* and labeled data; and the biochemistry data should include information such as activities and localization of enzymes. Grant applications must demonstrate that the needs of biological research teams will be addressed. The resultant software package should be available at modest cost, so that it is accessible to typical biological research teams.

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

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49. TECHNOLOGIES FOR SUBSURFACE CHARACTERIZATION AND MONITORING

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

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

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

- The Environmental Molecular Science Laboratory (EMSL) at the Pacific Northwest National Laboratory, (http://www.emsl.pnl.gov), 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.

- The Field Research Center (FRC) at Oak Ridge National Laboratory (http://www.esd.ornl.gov/nabirfrc/index.html) provides a DOE site location where scientists can conduct field scale research and obtain DOE-relevant samples of soils, sediments, and ground waters for laboratory research. A useful general orientation for prospective investigators is available at http://public.ornl.gov/nabirfrc/workshop2004_presentations.cfm.

Grant applications must describe, in the technical approach or work plan, the purpose and specific benefits of any proposed teaming arrangements. **Grant applications are sought only in the following subtopics:**

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

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

b. Real-Time, *In Situ* Biogeochemistry Measurements in Subsurface Sediments, Biofilms, or Groundwater—There is a need for sensitive, accurate, and real-time monitoring of changes in the composition of the microbial community and its metabolic potential, along with the monitoring of biogeochemical processes in contaminated subsurface environments, including sediments, biofilms, or ground water (hereafter referred to as the subsurface). To achieve this monitoring, highly sensitive *in situ* devices will be needed for use in the subsurface, particularly if they allow for low-cost field deployment in remote locations and an enhanced ability to monitor processes at finer levels of resolution. Therefore, grant applications are sought to develop innovative sensors and systems to detect biogeochemical processes that control the chemical speciation or transport of metals and radionuclides in the subsurface. For this subtopic, the following radionuclides and metals are of interest: americium, cesium, chromium, cobalt, mercury, plutonium, strontium, technetium, and uranium. Grant applications that address other contaminants will be declined. In addition, the microbes and metabolic processes of interest are limited to those that may be involved in controlling the subsurface fate, transport, and remediation of these elements. Grant applications must provide: (1) evidence of the relationship between the microbes and the contaminants; (2) 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 microbe, microbial association, or analyte (i.e., free of anticipated physical/chemical/biological interferences). Approaches that leave significant doubt

regarding sensor functionality in realistic multi-component samples will be excluded from consideration.

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

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

c. Improved Separation Technologies for Proteome Analyses of Subsurface Microbial Communities—Improved separation technology is needed to analyze the proteome of microbial communities in contaminated subsurface environments. The complexity of the proteome of these communities currently overwhelms the separation capabilities of commercial separation technologies. Therefore, grant applications are sought to exploit advances in capillary liquid chromatography (LC) separations, in order to improve the separation capacity and effectiveness. Approaches of interest include, but are not limited to, the use of: packing materials with reduced particle size, higher pressure (>10,000 psi) LC pumps, multiport valves that operate effectively at higher pressures (>10,000 psi), and more effective flow monitors for low flows (<200 nl/min). The ultimate goal is to provide greater peak capacity per unit time for the separation. Grant applications should include a discussion of how the proposed approach would eventually be integrated into a system to achieve improved separation.

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

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

50. ATMOSPHERIC MEASUREMENT TECHNOLOGY

World-wide energy production is modifying the chemical composition of the atmosphere and is linked with environmental degradation and human health problems. The radiative transfer properties of the atmosphere may be changing as well. The changes in chemical composition will require the development of atmospheric measurement techniques with high accuracy and/or time stability, in order to support a strategy of sustainable and pollution-free energy development for the future. Innovative measurement technology also will be needed, as input and comparison data, for models used to assess the radiative impacts of atmospheric components. Grant applications must propose Phase I bench tests of critical technologies with respect to the subtopics that follow. ("Critical technologies" refer to components, materials, equipment, or processes that overcome significant limitations to current capabilities.) For example, grant applications proposing only computer modeling without physical testing will be considered non-responsive. Grant applications also should describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities. Applications submitted to any of the subtopics should support claims of commercial potential for proposed technologies (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs). **Grant applications are sought only in the following subtopics:**

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

Therefore, 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) quantifiable results over a wide range of compounds – a problem for laser ablation aerosol mass spectrometer methods; (2) measurements over a range of volatility so that dust, carbon, and salt are detectable – a problem for thermal decomposition aerosol mass spectrometers; (3) speciation of individual organics, including those containing oxygen, nitrogen, and sulfur; (4) identification of elemental carbon and other carbonaceous material, so that the makeup of the absorbing fraction is known; (5) measurements with high time resolution – an inherent problem with filter techniques; (6) identification of source markers, such as isotopic abundances in aerosols; (7) the ability to probe the chemical composition of aerosol surfaces; and/or (8) improved measurements of aerosol chemical composition from airborne platforms.

Questions - contact Ashley D. Williamson (ashley.williamson@science.doe.gov)

b. Instrumentation for Characterizing Atmospheric Aerosols—In addition to chemical composition, improved or new instruments are needed for the measurement and understanding of other characteristics of atmospheric aerosols. Instruments that are suitable for use on airborne platforms are of specific interest.

(1) Aerosol precursors. Improvements in understanding gas phase chemistry are needed to further understand the evolution of aerosols in clouds. For example, gas phase measurements of H_2SO_4, a major aerosol precursor, have revealed a wealth of new information in the last decade. To make further progress, grant applications are sought to develop instruments that can make fast measurements of NH_3, ion clusters, and gas phase organics, substances that might either condense or dissolve into preexisting aerosols or cloud droplets. Of particular interest are measurements that can further segregate and organic substances into various classes – for example, segregation by volatility, water solubility, chemical class (alkanes, alkenes, aromatics, aldehydes, etc.) oxidation state, or functional groupings (nitrates, peroxides, etc.). Grant applications should identify any special instrument capabilities and describe the added value that they provide.

(2) Aerosol absorption. The aerosol absorption coefficient, together with the aerosol scattering coefficient, determines the single-scattering albedo. This key aerosol property, along with the factors that contribute to it, are critical for determining heating rates and climate forcing by aerosols. Therefore, grant applications are sought to develop reliable instruments for the *in situ* measurement of the single-scattering albedo for particles containing black and organic carbon, dust, and minerals. The measurements must cover the solar wavelengths (UV, visible, and near infrared), must not alter aerosol properties, and must address the influence of relative humidity. *In situ* measurements on particles in unperturbed local humidity environments must be combined with simultaneous measurement of local temperature and humidity. Of particular interest are instruments that can measure the aerosol optical properties over a range of known humidity states.

(3) 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 to determine the size distribution of ambient aerosols, in the 0.5-10 μm size range, that are not based on optical properties. The techniques must address the influence of relative humidity, as described in item (2) above, and, as appropriate, must simultaneously provide calculated values of such properties as mass, area (extinction), and number.

Questions - contact Ashley D. Williamson (ashley.williamson@science.doe.gov)

c. *In-Situ* Measurement of Cloud Properties with Large Sample Volumes—The response of clouds to climate change (the so-called "cloud feedback" problem) remains poorly understood, from both a measurement and a modeling point of view [Stephens, 2005]. Currently, there is a huge gap in the spatial scale between *in situ* measurements of cloud properties – typically from aircraft and balloons whose instruments have sample volumes on the order of cubic centimeters – and remote sensing retrievals of cloud properties – which have sample volumes ranging from tens of cubic meters (using radar and lidar) to thousands of cubic meters (using satellites). The most acute feature of this gap is that the *in situ* measurements at a particular point provide no information on the vertical distribution above and below that point, whereas the remote sensing retrievals typically provide instantaneous vertically-resolved information. Because clouds are inhomogeneous down to centimeter scales, simple assumptions of homogeneity, in order to scale up the *in situ* measurements, are certainly false. Consequently, there is a complete lack of comparability between the *in situ* measurements and remote retrievals. In addition, clouds evolve considerably in the course of one minute, and thus methods which are slow in time (such as a balloon ascending, or an aircraft ascending or descending) fail to capture the instantaneous state seen by remote sensing methods. Thus, there is a great need for in situ measurements which have fast vertical reach and much larger sample volumes, ranging from cubic meters to hundreds of cubic meters, in order to allow meaningful comparisons with surface and satellite retrievals of cloud properties. Without confidence in those surface and satellite retrievals, which are our only way to extend our reach to the whole planet, it is impossible to make progress on key global change issues concerning cloud feedbacks on global warming.

Therefore, grant applications are sought to develop instruments to measure cloud properties *in situ*, on scales ranging from cubic meters to hundreds of cubic meters, with particular emphasis on fast vertical profiling above and below the *in situ* platform. An example of such an instrument can be seen in Evans, et al. (2003). Measurements of the following cloud properties, in order of decreasing priority, are of particular interest for cloud-climate applications: (a) extinction coefficient at one or more wavelengths in the solar spectrum away from strong water vapor absorption bands; (b) total water content (liquid plus ice); (c) liquid and ice water content separately; (d) effective radius, defined as the ratio of the 3rd to the 2nd moment of the drop size distribution; (e) absorption coefficient or single-scattering albedo at one or more wavelengths in the solar spectrum away from strong water vapor absorption bands; (f) the scattering phase function for ice clouds; (g) the drizzle and precipitation fraction of the total condensed water content; (h) the supersaturation; and (i) the dispersion, a measure of the width of the drop size distribution. Grant applications also must account for the need to miniaturize the proposed instrumentation (in terms of both size and weight) for placement on aerial measurement platforms (e.g., aircraft, balloonsondes, small UAVs, kites, gliders, and tethered balloons).

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51. MEDICAL SCIENCES

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

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

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

Grant applications are sought only in the following subtopics:

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

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

b. Advanced Imaging Technologies—Grant applications are sought for new, sensitive, high-resolution instrumentation for radionuclide imaging. The instrumentation should advance the application of radiotracer methodologies for imaging molecular biological functions, including cell communication and gene expression *in vivo*. Areas of interest include the development of: (1) new detector materials and detector arrays for both positron emission and single photon emission computed tomography; (2) software for rapid image data processing and image reconstruction; and (3) methods of integrating *in*

vitro and *in vivo* instrumentation technologies for real time molecular imaging of biological function, and for new drug development and utilization.

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

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

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

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PROGRAM AREA OVERVIEW
OFFICE OF FUSION ENERGY SCIENCES

The Department of Energy sponsors fusion science and technology research as a valuable investment in the clean energy future of this country and the world, as well as to sustain a field of scientific research - plasma physics - that is important in its own right and has produced insights and techniques applicable in other fields of science and industry. The mission of the Fusion Energy Sciences (FES) program is to acquire the knowledge base needed for an economically and environmentally attractive fusion energy source. FES research efforts seek to: (1) understand the physics of plasmas, the fourth state of matter – plasmas constitute most of the visible universe, both stellar and interstellar, and progress in plasma physics has been the prime engine driving progress in fusion research; (2) identify and explore innovative and cost-effective development paths to fusion energy – the current fusion program encourages research on a wide range of approaches including the Tokamak (the leading power plant candidate), other magnetic configurations, and inertial fusion energy using particle beams, plasma beams, or lasers; and (3) explore the science and technology of energy producing plasmas, the next frontier in fusion research, as a partner in a international effort – reducing costs, avoiding duplication of

efforts, and bringing the best available scientific and engineering talent together to seek solutions to complex problems can best be done through the cooperative efforts of the world fusion community.

This is a time of important progress and discovery in fusion research. The U.S. has joined an international consortium, consisting of the European Union, Japan, China, Russia, Korea, and India, to fabricate and operate the next major step in the fusion energy sciences research program, a facility called "ITER." ITER will be designed to demonstrate a burning plasma. The FES program is making great progress in understanding turbulent losses of particles and energy across magnetic field lines used to confine fusion fuels, identifying and exploring innovative approaches to fusion power that may lead to more economical power plants and encouraging private sector interests to apply concepts developed in the fusion research program. It is felt that small businesses, by performing research within the following technical topics, can make significant contributions to these efforts. The following topics are restricted to science and technology relevant to magnetically confined plasmas and high energy density physics. Grant applications pertaining to fusion energy concepts not based specifically on the use of plasmas for producing energy/electricity for non-defense purposes will be declined.

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

52. ADVANCED TECHNOLOGIES AND MATERIALS FOR FUSION ENERGY SYSTEMS

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

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

either advanced, helium-cooled, refractory heat sinks or present-day, water-cooled, copper-alloy heat sinks.

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

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

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

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

b. **Blanket Materials and Systems—**The pebble-bed solid breeder configuration introduces several operational limits: thermo-mechanical uncertainties caused by pebble-bed wall interaction, potential sintering and subsequent macro-cracking, and a low pebble-bed thermal conductivity – all of which result in small characteristic bed dimensions and limit windows of operation. A new form of solid breeder morphology is required that holds the promise for increased breeding ratios – dictated by increased breeder material density; long term structural reliability; and enhanced operational control – compared to packed beds. Grant applications are sought for new solid breeder material concepts that include: (1) increased breeder material densities (>80%); (2) higher thermal conductivities (provided by a fully interconnected structure, as opposed to point contacts between pebbles); (3) better thermal contact, such as reliable bonded contact, with cooling structures (instead of point contacts between pebbles and wall); (4) the absence of major geometry changes between beginning-of-life and end-of life (such as sintering in pebble beds) in the presence of high neutron fluence; and (5) structural integrity in freestanding and self-supporting structures with significant thermo-mechanical flexibility.

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

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

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

c. Superconducting Magnets and Materials—New or advanced superconducting magnet concepts are needed for plasma fusion confinement systems; i.e., high field magnets (12 to 20 T) and low loss pulsed magnets. Grant applications are sought for: (1) innovative and advanced materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs; (2) cryogenic superconductor materials with high critical current density, low sensitivity to strain degradation effects, and radiation resistance; (3) novel, low-cost cable designs and fabrication

techniques, which minimize conductor strain; (4) superconducting joints for high field and pulsed applications; (5) novel, advanced sensors and instrumentation for non-invasively monitoring magnet and helium parameters (e.g., pressure, temperature, voltage, mass flow, quench, etc.); (6) thick (15-30 cm), weldable, cryogenic structural materials with high strength and toughness at 4 K; (7) welding techniques for such thick cryogenic structural materials; and (8) radiation-resistant electrical insulators (e.g., wrapable inorganic insulators and low viscosity organic insulators, which exhibit low out gassing under irradiation).

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

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

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

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

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

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

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

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

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

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53. 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. Diagnostics for Magnetic Fusion Plasma Research—Grant applications are sought to develop diagnostics for magnetic fusion research, including, but not limited to: (1) measurement techniques for parameters such as plasma density, electron and ion temperature, plasma current and current density, plasma position and shape, impurity density, magnetic field strength, ambipolar potentials, and radiation from the plasma; (2) new diagnostics for measurements in the three-dimensional plasmas characteristic of stellarators, as well as diagnostics especially adapted to other innovative confinement concept experiments; (3) diagnostic methods for examining the edge and divertor regions in tokamak plasmas, and for understanding electron thermal transport; and (4) diagnostics applicable to the management of particle and energy inventory, to profile control and thermal barrier formation, and to burning plasmas,

including ITER. Approaches of interest include new techniques, as well as methods to improve the accuracy and resolution of existing diagnostics (e.g., improving signal-to-noise ratio, extending the range of measured parameters, or measuring quantities at a level of detail greater than previously possible). The diagnostics research must be applicable to one or more of the following topical areas of magnetic fusion research: macroscopic plasma physics, multi-scale transport physics, plasma boundary interfaces, waves and energetic particles, and burning plasma physics.

Grant applications also are sought to apply diagnostics technology, developed for fusion energy, to the use of plasmas in manufacturing. These grant applications should show how the application of these diagnostics would contribute to the understanding of plasmas used in manufacturing.

Only applications proposing experimental research will be accepted. Applications proposing theory, computation, or modeling will be declined.

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

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

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

Questions - contact T.V. George (tv.george@science.doe.gov)

c. Plasma Simulation and Data Analysis—The simulation of fusion plasmas is important to the development of plasma discharge feedback and control techniques. The simulations can be used to make reliable predictions of the performance of proposed feedback and control schemes and to identify those that should be tested experimentally. Unfortunately, accurate simulations of fusion plasmas are very difficult because of the enormous range of temporal and spatial scales involved in plasma behavior. Considerable progress has been made in recent years in understanding and simulating plasma turbulence, along with associated transport, macroscopic equilibrium and stability, and the behavior of the edge plasma. However, there remains a need to integrate the various plasma models. Grant applications are sought to develop computer algorithms applicable to plasma simulations that account for an expanded number of plasma features and an integration of plasma models. Examples of possible approaches include algorithms that incorporate mathematical techniques such as neural networks, sparse linear solvers, and adaptive meshes; algorithms for coupling disparate time and space scales; efficient

methods for facilitating comparison of simulation results with experimental data; and visualization tools for local and remote analysis and presentation of multi-dimensional time dependent data.

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

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

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

d. Components and Modeling Support for Innovative Approaches to Fusion—Innovative Confinement Concepts is a broad-based, long-range research activity that specifically addresses approaches that could lead to the attractive and practical use of fusion power. This research includes investigations in stellarators, spherical torus, reversed field pinches, field reversed configurations (FRC), spheromaks, magnetized target fusion, levitated dipole, flow-stabilized (long-pulse) z-pinch, rotationally stabilized magnetic mirror, and inertial electrostatic confinement, as well as innovative approaches for driving currents, injecting magnetic flux and plasmas, fuelling and controlling flow in these devices. Grant applications are sought for scientific and engineering developments, including computational modeling, in support of any aspect of these research activities. Of particular interest are grant applications that explore the feasibility of plasma acceleration and injection into magnetic fields and/or magnetized plasmas, generation of plasma rotation, and disruption mitigation. Further information on experiments on innovative fusion concepts is available at the OFES Website.

Questions - contact Francis Thio (francis.thio@science.doe.gov)

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54. HIGH ENERGY DENSITY PHYSICS FOR INERTIAL FUSION ENERGY

Inertial fusion seeks to produce fusion reactions by creating plasmas of extremely high density and using inertia to contain momentarily the extreme pressure generated by the fusion burning plasma. In order for inertial fusion to achieve significant energy production, it will be necessary to develop attractive physics pathways for providing the necessary conditions for ignition and burn. In turn, these conditions will require states of matter with extremely high energy density (HED). For this purpose, HED states are defined as states of matter with energy densities exceeding about 10^{11} J/m^3 and temperature exceeding 1 eV. However, the physics of matter at such high energy densities is not well established – it is an emerging field that cuts across many areas of science. Therefore, the Office of Fusion Energy Sciences (OFES) sponsors research in heavy ion beams to produce these HED states, along with studies of the physics of fast ignition and high-temperature dense magnetized plasmas. This topic seeks to supplement the on-going research activities as well as to develop new techniques for creating or studying HED states relevant to the pursuit of inertial fusion energy. Proposals for the development of innovative diagnostics in support of the research are also welcome. Further information about research funded by the Office of Fusion Energy Sciences (OFES) can be found at the OFES Website: (**URL: WWW.OFES.FUSION.DOE.GOV**). **Grant applications are sought only in the following subtopics:**

a. Beam Generation, Compression, and Focusing—In current OFES programs, ion beams are produced by induction linear accelerators with components, in order to produce, accelerate, transport, and focus beams of required energy and intensity. Over the next few years, the research will concentrate on developing intense ion sources and on studying the physics of spatial compression, neutralized transport, and focusing of the beam. Grant applications are sought to support the development of high-current, high-brightness ion sources for heavy ion induction linacs. Grant applications also are sought for research in the spatial compression and focusing of high-current, high brightness ion beams. Approaches of interest include theoretical, computational, and/or experimental investigations.

Questions - contact Francis Thio (francis.thio@science.doe.gov)

b. Fast Ignition—The Fast Ignition concept employs two drivers to create inertial fusion: one for compression, and one for the ignition of a small portion of the compressed fuel. The main requirement and challenge for Fast Ignition is to deliver the ignition energy to the compressed fuel. In the most common approach, petawatt laser energy is nominally deposited in the coronal plasma surrounding the compressed fuel, resulting in a relativistic electron beam. Ignition depends on the successful propagation of that electron beam to the fuel and the effective heating of a small portion of that fuel. In this approach, the energy transport by relativistic electrons to the high-density fuel, in order to achieve ignition, is a key physics issue. An alternative approach, in which energetic ion beams are used as igniter beams, also is under consideration. Grant applications are sought for computational, experimental, and component development in support of these on-going Fast Ignition approaches. Grant

applications that address the development of petawatt lasers are outside the scope of this solicitation and will be declined.

Questions - contact Francis Thio (francis.thio@science.doe.gov)

c. Innovative Approaches for Creating and/or Studying States of High Energy Density—Grant applications are sought to develop innovative approaches for creating and/or understanding HED states. Areas of interest include, but are not limited to: (1) transport of thermal energy, kinetic energy, momentum, and particles in these states, especially the effects of externally applied or self-generated magnetic fields on the transport processes; (2) theoretical, computational, and/or experimental investigations for creating and/or using dense, high-Mach-number, high-velocity-plasma jets/beams to create HED states; and (3) generation and studies of highly intense magnetic fields (exceeding 500 T) in dense plasmas. Grant applications that address the development of petawatt lasers are outside the scope of this solicitation and will be declined.

Questions - contact Francis Thio (francis.thio@science.doe.gov)

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