PROGRAM AREA OVERVIEW: OFFICE OF DEFENSE NUCLEAR NONPROLIFERATION RESEARCH AND DEVELOPMENT

The Defense Nuclear Nonproliferation (DNN) mission is to provide policy and technical leadership to limit or prevent the spread of materials, technology, and expertise relating to weapons of mass destruction; advance the technologies to detect the proliferation of weapons of mass destruction worldwide; and eliminate or secure inventories of surplus materials and infrastructure usable for nuclear weapons. It is the organization within the Department of Energy's National Nuclear Security Administration (NNSA) responsible for preventing the spread of materials, technology, and expertise relating to weapons of mass destruction (WMD).

Within DNN, the Research and Development (R&D) program office sponsors long-term development of new and novel technology reduces the threat to national security posed by nuclear weapons proliferation and detonation or the illicit trafficking of nuclear materials. Using the unique facilities and scientific skills of NNSA and DOE national laboratories and plants, in partnership with industry and academia, the program conducts research and development that supports nonproliferation mission requirements necessary to close technology gaps identified through close interaction with NNSA and other U.S government agencies and programs. This program meets unique challenges and plays an important role in the federal government by driving basic science discoveries and developing new technologies applicable to nonproliferation, homeland security, and national security needs. DNN R&D has two sub-Offices: Proliferation Detection and Nuclear Detonation Detection.

The Office of Proliferation Detection (PD) is a mission-focused, applied research and development subprogram within NNSA's Defense Nuclear Nonproliferation R&D program. PD sponsors research and development, principally at the DOE National Laboratories, to develop advanced technical capabilities in support of U.S. national nuclear security and nonproliferation goals. PD efforts are aligned along three thrust areas: (1) advance U.S. technical capabilities to detect, characterize, and monitor the foreign production and movement of special nuclear materials (2) advance U.S. technical capabilities to detect, characterize, and monitor the foreign development of nuclear weapons and to support the nuclear counterterrorism and incident response mission, and (3) provide enabling capabilities for multi-use applications across the NNSA and interagency community.

The Nuclear Detonation Detection Office (NDD) produces, delivers and integrates the nation's operational sensors that monitor the entire planet from space to detect and report surface, atmospheric, or space nuclear detonations; advances seismic and radionuclide detection and monitoring capabilities that enable operation of the nation's ground-based nuclear detonation detection networks; and advances analytic nuclear forensics capabilities related to nuclear detonations.

1. REMOTE SENSING TECHNOLOGIES

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Office of Proliferation Detection (PD) is interested in developing new and novel technologies and concepts for early detection of nuclear weapons development, when on-site inspection is not possible. Specifically, we are interested in detecting, locating and characterizing facilities and activities associated with nuclear material processing – from mining to weaponization.

a. Passive Optical and Radar Tagging Materials for Remote Readout

The ability to remotely track objects has many applications, ranging from inventory/theft control to monitoring the location of vehicles and equipment. PD is soliciting new materials and concepts for tracking. The tags must themselves be passive, but the readout process may be based on active (e.g., laser, radar, incoherent sources) or passive (e.g., solar reflectance or fluorescence, infrared emissivity) technologies. The tags need not be unique, but must be easily discriminated from potential background clutter. Tags should be capable of line-of-sight detection and operate in the transparent portions of the atmospheric spectrum. Although not critical to this solicitation, other criteria that might be considered include:

- Ease of application (e.g., brush, spray or stick on)
- Resilience to environmental effects such as rain, sunlight and temperature extremes

Example materials include quantum dots, nanoparticles and infrared-emitting dyes, but need not necessarily be limited to these.

Questions - contact Victoria Franques, Victoria.Franques@nnsa.doe.gov

b. Efficient Algorithms for Combining Images from Different Sensor Systems

Technologies and services for remotely acquiring synthetic aperture radar imagery, multi- and hyper-spectral imagery, high resolution panchromatic imagery and video imagery are now becoming commercially available. PD is soliciting new algorithms and concepts for multimodal data fusion; specifically, developing the scientific basis for combining data streams from different imaging sensors. Consideration should be given to how the fused data might be analyzed for specific information such as identifying objects based on prior templates. For the sake of simplicity, assume that data streams are time-stamped, consist of two spatial dimension (pixels) and a third attribute (e.g., reflected solar intensity, reflected radar intensity/phase, spectral information, solar fluorescence).

Questions - contact Victoria Franques, Victoria.Franques@nnsa.doe.gov

c. Electromagnetic Signal Processing: Techniques and Classification Methodologies

Electromagnetic signals are generated by many processes and equipment. However, understanding, modeling and predicting the propagation and collection of these signals is limited by large amounts of clutter (co-located signals adding to the noise background) and the unknown influence of infrastructure along the path to collection.

PD is seeking new signal processing methods and techniques that can be used to reduce uncertainties of signal identification or extract signals of interest from noisy data sets. Methods and techniques to identify and classify patterns of signal activity through deep-learning frameworks and modelling (empirical and physics based) are desired, as well as, methods and techniques to discriminate signals of interest from background noise in large negative signal to noise ratio environments.

Questions - contact Daniel Mattei, Daniel.Mattei@nnsa.doe.gov

d. Other

In addition to the specific subtopics listed above, PD invites grant applications in other areas relevant to this Topic.

Questions - contact Victoria Franques, Victoria.Franques@nnsa.doe.gov

REFERENCES: Subtopic a:

1. Zhang, D., Brimrose Corporation, 2016, Covert IR Optical Taggants Enhance Identification, Photonics Media, (http://www.photonics.com/Article.aspx?AID=55844&PID=5&VID=116&IID=741)

REFERENCES: Subtopic b:

1. XpressSAR Inc., 2015, High Quality Geo-Information, Rapid Revisit High-Res All Weather, (http://www.xpresssar.com/#overview)

2. Airbus Defence and Space, 2016, Focus on the Essentials – Weather- Independent and in Near-Real-Time, TerraSAR-X Radar Satellite Imagery, (http://www.intelligence-airbusds.com/terrasar-x/)

3. MDA Information Systems LLC, 2016, NaturalVue 2000, (http://www.mdaus.com/satellite-imagery/naturalvue-2000)

4. HySpecIQ, Hyperspectral Intelligence, Homepage, (http://hyspeciq.com/)

5. Satellite Imaging Corporation, 2015, WorldView-2 Satellite Sensor, (http://www.satimagingcorp.com/satellite-sensors/worldview-2/)

6. DigitalGlobe, 2016, Our Satellite Constellation, (https://www.digitalglobe.com/about/our-constellation)

7. Lahat, D., Adalı, T., Jutten, C., 2015, Multimodal Data Fusion: An Overview of Methods, Challenges and Prospects, Proceedings of the IEEE, Institute of Electrical and Electronics Engineers, 2015, Multimodal Data Fusion, Volume 103, Issue 9, p.1449-1477. (https://hal.archives-ouvertes.fr/hal-01179853/file/Lahat_Adali_Jutten_DataFusion_2015.pdf)

REFERENCES: Subtopic c:

1. Hakimi, A., and Ellis, G.A., 2013, Equivalent Circuit Models for Propagation Analysis of In-Building Power line Communications Systems, Applied Computational Electromagnetics Society Journal, Volume 28, Issue 6, Pages 469-478. (https://www.ieee.org/index.html)

2. RADIOLOGICAL SOURCE REPLACEMENT

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Radiological source replacements are sought to mitigate the risk from accidental release or malicious use of commercial radioisotope sources, such as those found in medical irradiation systems, well logging applications, sterilization systems (for both food and insects), and industrial non-destructive testing and evaluation equipment. PD seeks proposals to develop alternative technologies that can replace or improve the functional capability of these systems without the use of radioisotopes.

a. Medical Linear Accelerator

PD is requesting a feasibility study for the design of a robust, medical linear accelerator (Linac) that will consistently operate in an environment with physical infrastructure challenges, such as unpredictable electrical power, environmental control (temperature and humidity), and water supply systems. The Linac should require minimal training to repair and operate, and should cost substantially less than available medical Linac systems. These requirements suggest a Linac that is relatively simple, consumes less power when on standby, produces less heat, requires low instantaneous power, and can smoothly transition to locally stored power during electricity interruptions. A modular design may be desirable if it allows local storage of easily installed replacement parts and/or the ability to upgrade the Linac as the sophistication of treatment by users improves.

Questions - contact Allen Bakel, Allen.Bakel@nnsa.doe.gov

b. Other

In addition to the specific subtopic listed above, PD invites grant applications in other areas relevant to this Topic.

Questions - contact Allen Bakel, Allen.Bakel@nnsa.doe.gov

REFERENCES:

1. The National Research Council, 2008, Radiation Source Use and Replacement, The National Academies Press, Washington D.C., 232 p. (http://www.nap.edu/catalog/11976.html)

2. Department of Energy, 2005, Report on Alternatives to Industrial Radioactive Sources, Report to the U.S. Congress, Under Public Law 109-58, The Energy Policy Act of 2005. (http://c.ymcdn.com/sites/www.productstewardship.us/resource/resmgr/imported/07-%20NE_Task_Force_Report_May_30.pdf)

3. Pomper, M.A., Dalnoki-Veress, F., Moore, G.M., 2016, Treatment, Not Terror: Strategies to Enhance External Beam Cancer Therapy in Developing Countries While Permanently Reducing the Risk of Radiological Terrorism, The Stanley Foundation, James Martin Center for Nonproliferation Studies, Washington, DC. (http://www.nonproliferation.org/treatment-not-terror/)

4. Atun, R., Jaffray, D.A., Barton, M.B., et al., 2015, Expanding Global Access to Radiotherapy, The Lancet Oncology, Volume 16, No. 10, p. 1153-1186. (http://www.thelancet.com/commissions/radiotherapy)

5. E.B., Podgorsak, 2015, Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, Austria, ISBN 92-0-107304-6. (http://www-pub.iaea.org/mtcd/publications/pdf/pub1196_web.pdf)

3. TECHNOLOGY TO FACILITATE NUCLEAR FORENSICS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Office of Nuclear Detonation Detection (NDD) is seeking to improve nuclear forensic capabilities in support of USG law enforcement and international partners. Specifically, these novel approaches will provide accurate, discriminating, timely, and robust technical information about interdicted materials, interdicted devices, and post-detonation signals.

a. Electronic Nuclear Forensics Recordbook

NDD is requesting a portable, wireless and secure "electronic nuclear forensics recordbook" (hereto called "recordbook") to enable agile nuclear forensics data collection and analysis reporting on an interdicted material by domestic and/or international law enforcement or other responders. This recordbook should be developed using "dummy inputs" as real inputs will not be provided during Phase I development. The recordbook could also include a software architecture that marries already-developed data tools such as i-phone/android applications or other software, stand-alone spectral analysis tools, data libraries, and report generators. The recordbook should have sufficient storage capacity (>1Tb) and be able to accommodate multiple formats for file sharing and editing. Example activities might include

calling up a standard operating procedure, recording collected on-scene evidence, querying data libraries and analysis tools to perform on-site analysis, recording on-site analysis results, communicating to a central nuclear forensics laboratory or control center for confirmation of results, and documenting sample packaging and transport back to a nuclear forensics laboratory.

The types of nuclear forensics information, instrumentation, and data that would be captured for a pre-detonation event by this recordbook are identified in IAEA Nuclear Security Series No. 22-G "Radiological Crime Scene Management"[1] and Nuclear Forensics in Support of Investigations, IAEA Nuclear Security Series No. 2-G, Rev 1 (2015). [2] An additional reference for the types of technical information that may be included is the Nuclear Forensic International Technical Working Group website. [3] Insight into post-detonation collection activities can be found in "Nuclear Forensics Analysis" by Kenton Moody, et al (2005).[4]

Grant applications responding to this topic should (1) identify the current state-of-the-art, in terms of relevant specifications for such type of electronic recordkeeping; (2) address the commercialization path of any software or components developed; and (3) address how to handle software and hardware obsolescence issues.

Questions - contact Donna Wilt, Donna.Wilt@nnsa.doe.gov

b. Other

In addition to the specific subtopic listed above, NDD invites grant applications in other areas that fall within the scope of the topic descriptions above.

Questions - contact Donna Wilt, Donna.Wilt@nnsa.doe.gov

REFERENCES:

1. IAEA, International Atomic Energy Agency, 2016, Nuclear Safety & Security, Nuclear Security Series Publications. (http://www-ns.iaea.org/security/nss-publications.asp)

2. IAEA, International Atomic Energy Agency, 2015, Implementing Guide, Nuclear Forensics in Support of Investigations, IAEA Nuclear Security Series, No. 2-G (Rev. 1), 80 p., Vienna, Austria, ISSN 1816-9317. (http://www-pub.iaea.org/books/IAEAbooks/10797/Nuclear-Forensics-in-Support-of-Investigations)

3. Nuclear Forensics International Technical Working Group (ITWG). http://www.nf-itwg.org

4. Moody, K.J., Grant, P.M., Hutcheon, I.D., 2014, Nuclear Forensic Analysis, 2nd edition, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 524 p., ISBN 9781439880616. (https://www.crcpress.com/Nuclear-Forensic-Analysis-Second-Edition/Moody-Grant-Hutcheon/p/book/9781439880616)

5. National Institute of Standards and Technology, U.S Department of Commerce, 2016, Projects/Programs, ANSI/IEEE N42.42 Standard. (https://www.nist.gov/programs-projects/ansiieee-n4242-standard)

4. TECHNOLOGY TO FACILITATE MONITORING FOR NUCLEAR EXPLOSIONS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Nuclear Detonation Detection Office (NDD) is seeking to improve capabilities for monitoring nuclear explosions, which are banned by several treaties and moratoria. These capabilities benefit the U.S. but may also benefit the international monitoring capabilities in the context of preparations for a Comprehensive Nuclear-Test-Ban Treaty (CTBT).

a. High-Reliability Whole-Air Gas Compressor

A near-zero-maintenance, high pressure (3,000 psig), high flow rate (variable between 2 to 300 standard liters per minute) whole-air gas compressor is needed to improve gas collection technologies used in environmental sampling applications and nuclear test-ban treaty monitoring technologies. This ultra-high-reliability whole-air compressor must outperform all other commercially available compressors in terms of regular maintenance and Mean-Time-Between-Failure (MTBF >5 years), and it must endure a wide range temperatures in storage (-18˚C to 54˚C) and operations (0˚C to 54˚C). The compressor must meet a power requirement of 115VAC/3Ø/400Hz/15 Amps per phase and 28 VDC/100 Amps. This call for an ultra-high-reliability compressor is intended to get high performance prototypes transferred to a manufacturer where they can be produced to raise the state-of-the-art of commercially available units. The compressors must be designed so a common commercial entity can build the compressor without high cost special machining. Finally, the compressor must be able to run at 100% duty cycle with ambient air-cooling and be able to maintain operation in high vibration environments (e.g., meet the intent of MIL-STD-810F 514.5 and 516.5 for an aircraft). The compressor must maintain adequate lubrication throughout the life of usage.

Grant applications responding to this topic must state (1) the current state-of-the-art, in terms of relevant specifications such as sensitivity, reliability, maintainability, etc., as well as the performance goal of the proposed advance in terms of those same specifications; and (2) address the commercialization path of any instruments or components developed. Due to the small market potential of treaty monitoring technologies, this call is focused toward already existing or emerging commercial products for other applications that could be modified/ enhanced for treaty monitoring applications. The resulting “treaty monitoring edition” of the product(s) would hopefully provide a performance advantage that would also benefit the original market and thereby leverage existing markets.

Questions - contact Leslie Casey, Leslie.Casey@nnsa.doe.gov

b. Other

In addition to the specific subtopic listed above, NDD invites grant applications in other areas that fall within the scope of the topic descriptions above.

Questions - contact Leslie Casey, Leslie.Casey@nnsa.doe.gov

REFERENCES:

1. U.S. National Data Center, Air Force Technical Applications Center (http://www.usandc.gov)

PROGRAM AREA OVERVIEW: OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY

The Office of Electricity Delivery and Energy Reliability (OE) provides national leadership to ensure that the Nation's energy delivery system is secure, resilient, and reliable. OE works to develop new technologies to enhance the infrastructure that brings electricity into our homes, offices, and factories and to improve the federal and state electricity policies and programs that shape electricity system planning and market operations. OE also works to bolster the resiliency of the electric grid and assists with restoration when major energy supply interruptions occur.

OE recognizes that our Nation's sustained economic prosperity, quality of life, and global competitiveness depend on access to an abundance of secure, reliable, and affordable energy resources. The mission of OE is to drive electric grid modernization and resiliency in the energy infrastructure. Through a mix of technology and policy solutions, OE will address the changing dynamics and uncertainties in which the electric system will operate. OE leverages effective partnerships, solid research, and best practices to address diverse interests in achieving economic, societal, and environmental objectives.

OE has a broad portfolio of activities that spans technology innovation, institutional support and alignment, and security and resilience. Serving as the lead for the Department of Energy's efforts on grid modernization, OE works closely with diverse stakeholders to ensure that clean energy technologies can be integrated in a safe, reliable, and cost-effective manner.

For additional information regarding OE's activities and priorities, click here.

Further information regarding the challenges and needs associated with the Nation's energy infrastructure can be found in the 2015 releases of the Department's Quadrennial Energy Review and Quadrennial Technology Review.

5. ADVANCED GRID TECHNOLOGIES

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The electric power grid is facing increasing stress due to fundamental changes in both supply-side and demand-side technologies. On the supply-side, there is a shift from large synchronous generators to smaller, lighter units (e.g., gas-fired turbines) and variable energy resources (e.g., renewables). On the demand-side, there is a growing number of distributed energy resources, as well as a shift from large induction motors to rapidly increasing use of electronic converters in buildings, industrial equipment, and consumer devices. The monitoring and control systems used for operations are also transitioning from analog systems to systems with increasing data streams and more digital control and communications; from systems with a handful of control points at central stations to ones with potentially millions of control points.

Grid modernization will require the adoption of advanced technologies, such as smart meters, automated feeder switches, fiber optic and wireless networks, energy storage, and other new hardware. It must also encompass and enable the application of intelligent devices, next-generation components, cybersecurity protections, advanced grid modeling and applications, distributed energy resources, and innovative architectures. Integration of these technologies will require a new communication and control layer to manage a changing mix of supply- and demand-side resources, evolving threats, and to provide new services.

The transition to a modern grid will create new technical challenges for an electric power system that was not designed for today's requirements. Customers have never relied more on electricity, nor been so involved in where and how it is generated, stored, and used. Utilities will continue retrofitting the existing infrastructure with a variety of smart digital devices and communication technologies needed to enable the distributed, two-way flow of information and energy. Reliability, resilience, and security will remain a top priority as aging infrastructure and changing demand, supply, and market structures create new operational challenges.

All applications to this topic should:

- Be consistent with and have performance metrics (whenever possible) linked to published, authoritative analyses in your technology space.
- Clearly define the merit of the proposed innovation compared to competing approaches and the anticipated outcome.
- Emphasize the commercialization potential of the overall effort and provide a path to scale up in potential Phase II follow-on work.
- Include quantitative projections for price and/or performance improvement that are tied to representative values included in authoritative publications or in comparison to existing products.
- Fully justify all performance claims with thoughtful theoretical predictions and/or experimental data.

Grant applications are sought in the following subtopics:

a. Electrical Protection Scheme Reliability Assessment and Evaluation

The reliability of an electric transmission or distribution system in response to a fault is heavily dependent upon the underlying protection scheme that is being utilized to identify and respond to that fault. However, if a component or device fail to respond properly within the protection scheme due to improper settings, sensor failure or inaccuracy, communications failure within the substation or with adjacent facilities, or other material failure or compromise, little is known or understood of the potential consequences. Additionally, the greater penetration of distributed energy resources (DER) is introducing additional fault currents and new conditions that existing protection schemes were not designed to handle.

This topic is looking to develop methodologies, processes, and tools that will help assess the reliability of transmission and distribution protection schemes, and evaluate them based on metrics such as resiliency, dependability, redundancy, costs, efficacy, and flexibility. In addition to linear systems, the mechanism proposed should be able to assess and evaluate networked systems and account for the presence of DER, including energy storage. Collaboration with protection device manufacturers and utility protection engineers is strongly encouraged.

Questions - contact David Howard, david.howard@hq.doe.gov

b. Rapid Damage Assessment and Information Sharing for Power Restoration

One of the many challenges electric utilities face during and after a catastrophic event such as a hurricane or an earthquake is the lack of immediate access to their infrastructure to perform damage assessments. Deployment of repair crews, movement of heavy equipment, and other response and recovery decisions are based on these assessments. Floods, damaged roads, and other unsafe conditions that denies access or puts workers at risk can hinder this critical step. Delays and inaccuracies in damage assessment will negatively impact situational awareness, decision making, and ultimately, power restoration times.

Additionally, repair crews are provided by other utilities to assist in the response and recovery efforts under mutual aid agreements during catastrophic events. These visiting crews might not be familiar with the specific details of the impacted utility's system, and damaged and missing components adds to the difficulty of coordinating an efficient restoration effort. Improved information sharing and real-time situational awareness can help manage resources better, and should be encapsulated by the damage assessment process.

This topic is looking for solutions that can improve the timeliness and accuracy of damage assessments (i.e., 80% accuracy within 12 hours, 90% accuracy within 24 hours), including improved information sharing and enhanced situational awareness. Potential options might include but is not limited to the use of smart aerial technologies, robotics, satellite imaging, advanced sensing, augmented reality, data mining, or some combination of the above.

Questions - contact Stewart Cedres, stewart.cedres@hq.doe.gov

REFERENCES: Subtopic a:

1. Schweitzer, E.O., III, Fleming, B., Lee, T.J., Anderson, P.M., 1997, Reliability Analysis of Transmission Protection Using Fault Tree Analysis Methods, 24th Annual Western Protective Relay Conference, SEL and Power Math Associates, USA, p. 18. (https://selinc.cachefly.net/assets/Literature/Publications/Technical%20Papers/6060_ReliabilityAnalysis_Web.pdf?v=20151204-152929)

2. Scheer, G.W., Schweitzer Engineering Laboratories, Inc, 1998, Answering Substation Automation Questions Through Fault Tree Analysis, 4th Annual Substation Automation Conference, p. 30.

(https://cdn.selinc.com/assets/Literature/Publications/Technical%20Papers/6073_AnsweringSubstation_Web.pdf)

3. Sandoval, R., Santana, C.A.V., Schwartz, R.A., et al., 2010, Using Fault Tree Analysis to Evaluate Protection Scheme Redundancy, 37th Annual Western Protective Relay Conference, p. 21. (https://selinc.cachefly.net/assets/Literature/Publications/Technical%20Papers/6461_UsingFaultTree_HA_20101018_Web.pdf?v=20150812-082037)

4. Depablos, J., Ree, J.D.L., Centeno, V., 2004, Identifying Distribution Protection System Vulnerabilities Prompted by the Addition of Distributed Generation, 2nd International Conference on Critical Infrastructures, Grenoble, p. 3. (http://www.history.vt.edu/Hirsh/CentenoPower1.pdf).

5. Sakis Meliopoulos, A. P., Yang, F., Cokkinides, G. J., Binh Dam, Q., 2006, Effects of Protection System Hidden Failures on Bulk Power System Reliability, 2006 38th North American Power Symposium, IEEE. (http://ieeexplore.ieee.org/document/4201364/)

6. McCalley, J., Oluwaseyi, O., Krishnan, V., et al., 2010, System Protection Schemes: Limitation, Risks, and Management, Final Project Report, Power Systems Engineering Research Center (PSERC), p. 6. (https://www.researchgate.net/publication/277330229_System_Protection_Schemes_Limitations_Risks_and_Management)

7. Azarm, M.A., Bari, R., Yue, M., Musicki, Z., 2004, Electrical Substation Reliability Evaluation with Emphasis on Evolving Interdependance on Communication Infrastructure, 8th International Conference on Probabilistic Method Applied to Power Systems, Brookhaven National Laboratory, BNL-73108-2004-CP. (https://www.bnl.gov/isd/documents/26662.pdf)

8. Wang, F., 2012, Reliability Evaluation of Substations Subject to Protection Failures, Delft University of Technology, Delft, the Netherlands, p. 110. (http://repository.tudelft.nl/islandora/object/uuid:ca5075ff-c0ed-4f54-9b5e-db17eb0fc3cb/?collection=research)

9. Kezunovic, M., 2006, A Survey of Engineering Tools for Protective Relaying, Electra N 225, p. 26-30. (http://smartgridcenter.tamu.edu/resume/pdf/j/electra06.pdf)

REFERENCES: Subtopic b:

1. Kullmann, J., 2013, Survey: Damage assessment key to effective outage restoration, Electric Light & Power Magazine. (http://www.elp.com/articles/print/volume-91/issue-1/sections/survey-damage-assessment-key-to-effective-outage-restoration.html)

2. Electric Power Research Institute (EPRI), 2016, Electric Power System Resiliency – Challenges and Opportunities, p. 15. (https://www.naseo.org/Data/Sites/1/resiliency-white-paper.pdf)

3. U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability, Emergency Situational Reports, 2003-2016. (http://www.oe.netl.doe.gov/emergency_sit_rpt.aspx)

4. Electricity Advisory Committee (EAC), 2015, Memorandum to Assistant Secretary for Electricity Delivery and Energy Reliability, Recommendations on Smart Grid Research and Development Needs, p.40. (http://energy.gov/sites/prod/files/2015/04/f21/EAC%20Recommendations%20on%20Smart%20Grid%20Research%20and%20Development%20Needs.pdf)

5. Electric Power Research Institute (EPRI), 2008, Future Inspection of Overhead Transmission Lines, Technical Update, p. 88, 1016921. (http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001016921)

6. Dominion Virginia Power, 2016, Unmanned Aerial Inspections. (https://www.dom.com/residential/dominion-virginia-power/customer-service/unmanned-aerial-inspections)

PROGRAM AREA OVERVIEW: OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

The Office of Energy Efficiency and Renewable Energy (EERE) is at the center of creating the clean energy economy today. EERE leads the U.S. Department of Energy's efforts to develop and deliver market-driven solutions for energy-saving homes, buildings, and manufacturing; sustainable transportation; and renewable electricity generation.

The EERE mission is to strengthen America's energy security, environmental quality, and economic vitality in public-private partnerships to 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'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. EERE Technology Office efforts directly support the President's goals of doubling renewable electricity generation by 2020 and doubling energy productivity by 2030. On September 17, 2014, U.S. Secretary of Energy Moniz announced a partnership with the Council on Competitiveness and the Alliance to Save Energy to launch Accelerate Energy Productivity 2030 to grow our economy while reducing our energy costs.

EERE's Technology Offices all have multiyear plans, detailed implementation processes and have demonstrated impressive results. Program activities are conducted in partnership with the private sector (including small businesses), state and local governments, 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. EERE's fiscal year 2016 budget request can be found here: http://energy.gov/articles/energy-department-presents-fy16-budget-request.

6. BUILDINGS & SOLAR JOINT TOPIC: SOLAR BUILDING ENERGY STORAGE MANAGEMENT

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Multiple offices within the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) are interested in the development and wider deployment of software solutions that unlock the potential for battery energy storage in commercial and industrial buildings. Battery energy storage has the potential to increase the flexibility of electric loads in commercial, industrial, and residential buildings to reduce electricity service costs, aid the integration of renewable energy, and improve the resiliency of the electric grid [1] [2]. By storing electric energy for later use, battery storage can enhance existing building energy technologies such as controllable electric loads and distributed energy generation. As battery

technology continues to develop, the building sector would benefit from software solutions that enable the integration of battery storage with connected electric loads and/or distributed generation technologies [2]. At the same time, there is a need to adequately monitor and model the operation of diverse battery technologies to ensure their reliability, safety, and longevity in building applications [3].

a. Software Innovations for Monitoring and Control of Battery Energy Storage in Commercial and Industrial Buildings

The Buildings Technologies Office (BTO) and Solar Energy Technology Office (SETO) seek to collaborate in the development and commercialization of software innovations that will reduce the cost and improve the value and performance of battery energy storage. As a joint area of interest, this topic will enable the leveraging of BTO and SETO goals, specifically, reducing buildings' energy use in concert with making solar energy cost-competitive with other forms of electricity, through advancements in battery energy storage solutions for solar-powered commercial and industrial buildings.

While energy storage used in commercial and industrial buildings has the potential to reduce electricity service costs, provide flexibility to the grid system, and improve grid resiliency, there is a major software challenge associated with realizing these benefits [2] [3]. Applications are sought that will address current limitations of battery storage management software in effectively coordinating storage with electric load and generation to provide demonstrable benefits to the building owner in the form of economic savings, increased reliability, or richer information about building energy management. Robust software platforms that allow grid operators and/or utilities to reliably and routinely procure services from building energy storage without disrupting the supply of energy to the building and its occupants are also desired. Moreover, this topic seeks software solutions that can adequately model and/or monitor diverse battery technologies and enable their integration with a common platform for building energy management and the interactions between buildings and the electric grid.

Applicants should address the following characteristics in their proposed solutions as applicable:

- Focus on leveraging software to enhance the interoperability of battery energy storage with electric loads and generators, and existing utility tariffs and electricity market opportunities.
- Identify the potential for software to increase the value of battery energy storage to building owners and to the wider grid system.
- Discuss how software could be used to monitor and control battery technologies in building applications.
- Address the potential for battery energy storage to coordinate with automated loads and building energy management systems to provide demand response or other grid services.

- Address the potential for battery energy storage to coordinate with on-site electric vehicle charging or solar energy generation.
- Address the potential to use battery energy storage to aggregate and offer building energy services to the electric utility or grid operator as a single controllable entity.

Questions - contact Sven Mumme, sven.mumme@ee.doe.gov

REFERENCES: Subtopic a:

1. Akhil, A.A., Huff, G., Currier, A.B., et al., 2015, DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA, Sandia Report, Sandia National Laboratories, p. 347 (http://prod.sandia.gov/techlib/access-control.cgi/2015/151002.pdf)

2. Kirchev, A., 2015, Battery Management and Battery Diagnostics, Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Elsevier B.V, p. 411-435, ISBN: 978-0-444-62616-5. (http://www.sciencedirect.com/science/article/pii/B9780444626165000206)

3. U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability, 2013, Grid Energy Storage. (http://energy.gov/oe/downloads/grid-energy-storage-december-2013)

7. GEOTHERMAL & BUILDINGS JOINT TOPIC : GEOTHERMAL HEAT PUMPS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Multiple offices within the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) are interested in the development and wider deployment of Geothermal Heat Pump (GHP) systems. GHP systems first gained popularity during the energy crisis in the 1970's, but despite having proven energy saving potential, they have only had limited market penetration. Barriers such as the high installation costs, due largely to the high costs of installing the ground loop, have prevent GHP systems from realizing a potential of 3.7 quads in primary energy savings.

a. Innovations to Improve Geothermal Heat Pump Ground-Loop Cost and Performance

The Geothermal Technologies Office (GTO) and Buildings Technologies Office (BTO) collaborate to seek the development and commercialization of innovations that will reduce the cost and/or improve performance of GHP systems' ground loops. GHP systems achieve high efficiency by utilizing the relatively stable temperatures below the Earth's surface as a thermal source and sink. Because the ground maintains a moderate temperature year-round compared to ambient air, the GHP system can transfer heat over a smaller temperature difference, raising efficiency in both the heating and cooling seasons. Despite this inherent efficiency advantage, GHP systems have been limited by the high initial cost of the ground loop installation and the site-specific assessment and engineering design

requirements that must carefully consider the building heating and cooling loads in the overall ground-loop design.

Innovations may include, but are not limited to, advances in heat exchangers, integrated design and simulation tools, improved installation techniques, and lifecycle energy and cost evaluation tools. As part of their proposals, applicants should quantify the state of the art metrics relevant to their innovation and estimate the improvements possible if the proposed innovation is successful. DOE is seeking improvements of 25% or more over current state of the art. While the DOE is open to innovations that specialize in a specific climate zones (e.g. cold-climate, hot-dry, or hot-humid), the commercialization plan must show the ability to deploy the innovation to a wider geographic area so it could make a significant impact on the United States GHP industry.

Questions - contact Arlene Anderson, arlene.anderson@ee.doe.gov

REFERENCES: Subtopic a:

1. U.S. Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program, 2012, Research and Development Roadmap: Geothermal (Ground-Source) Heat Pumps, p. 49. (http://www1.eere.energy.gov/buildings/pdfs/ghp_rd_roadmap2012.pdf)

2. Goetzler, W., Guernsey, M., and Young, J., 2014, Research & Development Roadmap for Emerging HVAC Technologies, U.S. Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Office, p. 121. (http://energy.gov/sites/prod/files/2014/12/f19/Research and Development Roadmap for Emerging HVAC Technologies.pdf)

3. Ballard, M., 2009, Geothermal Heat Pump, Research and Development Initiative, OGE Energy Corporation, p. 15. (http://www.igshpa.okstate.edu/geothermal/research/OGE Ground Source Heat Exchange Initiative.pdf)

8. ADVANCED MANUFACTURING

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Advanced Manufacturing Office (AMO) (www1.eere.energy.gov/manufacturing/) collaborates with industry, small business, universities, and other stakeholders to identify and invest in emerging technologies with the potential to create high-quality domestic manufacturing jobs and enhance the global competitiveness of the United States.

Applications may be submitted to any one of the subtopics listed below but all applications must:

- Propose a tightly structured program which includes technical milestones that demonstrate clear progress, are aggressive but achievable, and are quantitative;

- Include projections for price and/or performance improvements that are tied to a baseline and/or state of the art products or practices);
- Explicitly and thoroughly differentiate the proposed innovation with respect to existing commercially available products or solutions;
- Include a preliminary cost analysis;
- Justify all performance claims with theoretical predictions and/or relevant experimental data

Grant applications are sought in the following subtopics:

a. Surface Compatibility of Cellulosic Nanomaterial in Hydrophobic Matrix Materials

This subtopic is focused only on Cellulosic Nanomaterial (CN) fiber-reinforced thermoplastic composite applications. This subtopic seeks applications that: i) demonstrate scalability of surface and/or resin modification methods at a minimum of kilogram scale, ii) perform techno-economic analysis of feasibility to produce lightweight transportation or clean energy (wind, solar, geothermal, fuel cell, heat recovery, etc.) system components at high volume in commercially available fabrication systems. Available fabrication systems include injection molding, compression molding, resin transfer molding, and 3D printing/additive manufacturing. The fiber alignment ability of treated fibers/resins should also depend on target requirements.

Cellulose nanocrystals (CNCs) are rigid crystals with diameter of 3-10 nm and aspect ratio greater than 5 and less than 50. Cellulose nanofibrils (CNFs) contain both crystalline regions and amorphous regions with diameters of 5-30 nm and an aspect ratio greater than 50 [1]. Although the main focus of this subtopic is on the use of CNFs, use of CNCs will also be considered.

CNFs have two main deficiencies. There are a large number of hydroxyl groups, which produce strong hydrogen interactions between CNFs that leads to a gel-like structure when produced. Also, CNFs high hydrophilicity limits its uses in composites as they can form agglomerates in petro-chemical polymers. The majority of polymer resins used in high volume applications such as in automotive are hydrophobic and dispersion of highly hydrophilic cellulosic nanomaterials in these materials is a barrier to adoption [2]. Environmentally benign and scalable surface modifications and resin formulations are needed to address this barrier through management of interfacial properties and composite manufacturing technologies.

Production of cellulosic nanomaterials has transitioned from laboratory to pilot scale. There are now a significant amount of emerging suppliers as well as ongoing research and applications development ongoing worldwide [3]. For this subtopic, low-cost cellulosic nanomaterials are preferred as source materials. Applications must demonstrate potential for economically feasible high volume production of composite components. CNF reinforced thermoplastic composites should be competitive on a cost per performance basis

with glass fiber and moderate-strength carbon fiber reinforcements. Costs of reinforcement material should be less than $5/pound at high volume production rates. The applicant should integrate input from the material supplier in its economic feasibility model and characterize the consistency of as-received cellulosic materials. The applicant must be able to provide details on desired material characteristics. Targeted system mechanical properties and end user requirements should also be identified in the application.

Questions – contact Stephen Sikirica, Stephen.Sikirica@ee.doe.gov

b. Intelligent Systems for Materials Discovery

Combinatorial methods of materials screening provide rapid analyses of large numbers of samples of diverse materials such as coatings, catalysts, and pharmaceuticals. A number of exceptional discoveries have been made with the application of combinatorial methods. Although these methods are rapid and provide vast amounts of information – they provide no insight into the underlying mechanisms or the process for discovering more such processes.

The availability of increasing digital computational capability and algorithms that can make use of this capability has dramatically expanded the possibilities for machine learning and artificial intelligence. Such capabilities have yet to be coupled with combinatorial methods of materials discovery, and this is the focus of this subtopic.

Investigators from small businesses are invited to collaborate with other researchers in the materials and computational sciences to develop combinatorial discovery systems that are aided by artificial intelligence to expand the ease and scope of combinatorial discovery methods. This subtopics' objective is to make combinatorial discovery methods more accessible to investigators who need to develop or improve new materials by interpreting data obtained in combinatorial searches with machine learning and directing the search toward desired objectives. We expect that the result of the R&D effort will be a system that can be commercialized and sold to investigators with specific materials development objectives and needs.

Interdisciplinary teams of investigators are invited to submit Phase 1 research proposals in the following areas:

- Heterogeneous catalyst discovery: Systems for combinatorial discoveries and improvements of heterogeneous catalysts are widely available, and systems to guide catalyst discoveries with the aid of artificial intelligence are solicited. All types of heterogeneous catalysts are covered by this subtopic area – including electrocataysts for fuel cells and chemical catalysts used in industrial chemistry.
- Polymer discovery: Large numbers of polymer samples are typically analyzed for various coatings and other applications; intelligent systems to guide this search process is

solicited. This would greatly reduce the time needed in combinatorial searches of polymeric materials for a desired end use.

- Thin films for energy applications: Applications for thin film semiconductor and dielectrics used in photovoltaic applications, fuel cells are solicited. etc. Many combinations of thin film materials are used to improve the performance of energy conversion devices, and routinely assayed by combinatorial methods.
- Other energy related materials such as thermoelectrics, thermocalorics, magnetic materials, and supercapacitors: These materials are sorted using combinatorial methods to find those that improve the performance of numerous renewable energy conversion systems.
- Small molecule drug discovery: The number of possible geometric, stereo, and enantio isomers of small molecules increases factorially with the number of constituent atoms, making the discovery of small molecules with desired pharmaceutical properties arduous and time consuming and typically involving thousands of samples in combinatorial libraries. Artificial intelligence applied to guide the search through interpretation of the data obtained in the search would be of great benefit to those involved in the drug discovery process. This subtopic is for the discovery system only, and any regulatory aspects of the development of a commercial system must be addressed by the investigators in conjunction with the appropriate Federal regulatory agencies.

Questions – contact Brian Valentine, Brian.Valentine@ee.doe.gov

c. Atomically Precise Structures and Devices for Catalysis

Advances in the design and synthesis of atomically-precise enzyme-like catalytic structures offer the potential for efficient transformation of low-cost chemicals to high value products [1-4]. We seek atomically precise approaches to advance catalyst technology. For the purpose of this opportunity, the term "atomically precise" is defined as virtually defect-free structures and devices, where every atom and bond is at a specified location and orientation, and there are essentially no impurities or defects in the functional portions. This includes but is not limited to Spiroligomers, Metal Organic Frameworks, engineered proteins, enzymes, ribozymes, and engineered DNA and RNA. While nanoparticles may act as useful substrates for atomically precise catalysts, note that most nanoparticles are not atomically precise and therefore would not qualify as enzyme-like catalytic structures without significant modification or new synthetic approaches for their manufacture. "Enzyme-like" refers to the fact that enzymes have evolved highly-efficient receptor sites and potential energy surfaces to bring chemical reactants together in favorable positions and orientations. The method of synthesis of these atomically precise catalytic structures should allow scalable, high yield production as in most commercial synthetic chemistry processes. We seek applications of high energy impact at a national level.

Areas of particular interests include:

Photocatalysis of water without using sacrificial reagents. Proposed approaches should require less than half the energy consumption of best-in-class systems (e.g., $NaTaO_3$:La) for equivalent production of H_2 and O_2.

Ammonia production. Proposed approaches should require less than half the energy consumption of the commercial ammonia synthesis loop $3H_2 + N_2 \rightarrow 2NH_3$ (Haber-Bosch process). As AMO is exploring atomically precise methods for high purity gas separations in other subtopics, the traditional issues of sulfur poisoning and oxygen contamination of the nitrogen supply do not necessarily have to be addressed in applications to this area of interest. However, atomically precise catalyst design should provide for appropriate protection of the reaction site to avoid unwanted side reactions and back reaction, and transport of the reactants and product to and from the site.

Novel Catalytic Routes to Direct Synthesis of Carbon Fiber from Gas or Solution Phase. As a deliverable, a minimum of 25% improvement in energy intensity over fiber production in current commercial practice must be demonstrated. This should be done through the physics-based design and synthesis of atomically precise solid catalysts, with sufficient experimental measurements and supporting calculations to show that the technology could feasibly synthesize low defect carbon fiber, and that cost-competitive energy savings could be achieved with practical economies of scale. The application should provide a path to demonstration of synthesis of carbon fiber (if not actual synthesis), and to process scale up in potential Phase II follow on work.

Low temperature production of chemicals from hydrocarbons. Proposed methods should result in energy consumptions that approach the practical minima outlined in [5].

Questions – contact David Forrest, David.Forrest@ee.doe.gov

REFERENCES: Subtopic a:

1. TAPPI, Proposed New TAPPI Standard: Standard Terms and Their Definition for Cellulose Nanomaterial, Draft, WI 3021. (http://www.tappi.org/content/hide/draft3.pdf)

2. Missoum, K., Belgacem, M.N., and Bars, J., 2013, Nanofibrillated Cellulose Surface Modification: A Review, Materials, Volume 6, Issue 5, p. 1745-1766, doi:10.3390/ma6051745. (http://www.mdpi.com/1996-1944/6/5/1745)

3. 2015, Summary of International Activities on Cellulosic Nanomaterials, Contribution of ISO/TC 6/TG 1 – Cellulosic Nanomaterials, p. 73. http://www.tappinano.org/media/1096/tc6-world-cnm-activities-summary-july-29-2015.pdf

REFERENCES: Subtopic b:

1. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, About the Energy Materials Network. (http://energy.gov/eere/energy-materials-network/about-energy-materials-network)

2. Executive Office of the President of the United States, 2014, Materials Genome Initiative National Science and Technology Council Committee on Technology Subcommittee on the Materials Genome Initiative, Materials Genome Initiative Strategic Plan, Technical Report NMAB-501, Washington, DC, p. 65. (https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/mgi_strategic_plan_-_dec_2014.pdf)

3. Hemminger, J., Crabtree, G. W., Kastner, M., 2008, New Science for a Secure and Sustainable Energy Future, A Report of a Subcommitee to the Basic Energy Sciences Advisory Committee, Office of Basic Energy Sciences, U.S. Department of Energy, p. 24. (http://science.energy.gov/~/media/bes/pdf/reports/files/New_Science_for_a_Secure_and_Sustainable_Energy_Future_rpt.pdf)

REFERENCES: Subtopic c:

1. Hermans, S., and Visart de Bocarme, T., 2014, Atomically-Precise Methods for Synthesis of Solid Catalysts, Royal Society of Chemistry, London, ISBN: 978-1-84973-829-3 (http://pubs.rsc.org/en/content/ebook/978-1-84973-829-3#!divbookcontent)

2. U.S. Department of Energy, Office of Basic Energy Sciences, Energy Frontier Research Center, LSU, 2012, Wet Chemical Synthesis of Atomically Precise Nanocatalysts. (http://www.efrc.lsu.edu/project1.html)

3. U.S. Department of Energy, Argonne National Laboratory, 2012, Institute for Atom Efficient Chemical Transformations- an Energy Frontier Research Center. (http://www.iact.anl.gov/)

4. U.S. Department of Energy, Pacific Northwest National Laboratory, 2016, Center for Molecular Electrocatalysis, Tackling Our Energy Challenges in a New Era of Science Latest Announcements. (http://efrc.pnnl.gov/)

5. U.S. Department of Energy, Energy Efficiency & Renewable Energy, 2015, Bandwidth Study on Energy Use and Potential Energy Saving Opportunities in U.S. Chemical Manufacturing, p. 146. (http://www.energy.gov/sites/prod/files/2015/08/f26/chemical_bandwidth_report.pdf)

9. BIOENERGY

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Biomass is a clean, renewable energy source that can significantly diversify transportation fuels in the United States. The U.S. Department of Energy's Bioenergy Technologies Office (BETO) (http://energy.gov/eere/bioenergy) is helping to transform the nation's renewable and abundant biomass resources into cost-competitive, high-performance biofuels, bioproducts, and biopower. BETO is focused on forming partnerships with key stakeholders to develop, demonstrate, and deploy technologies for advanced biofuels production from lignocellulosic and algal biomass.

All applications to this topic must:

- Be consistent with and have performance metrics (whenever possible) linked to BETO's recently updated Multi-Year Program Plan (MYPP) that is available for download directly at: http://www.energy.gov/sites/prod/files/2016/07/f33/mypp_march2016.pdf
- Clearly define the proposed application, the merit of the proposed innovation, and the anticipated outcome with a special emphasis on the commercialization potential of the overall effort including Phase I and Phase II;
- Applications should provide a path to scale up in potential Phase II follow on work.
- Include quantitative projections for price and/or performance improvement that are tied to representative values included in the MYPP or in comparison to existing products. For example, projections of price or cost advantage due to manufacturing improvements, materials use, or design simplification should provide references to current practices and pricing to enable informed comparison to present technologies.
- Fully justify all performance claims with thoughtful theoretical predictions or experimental data.

a. Biofuel and Bioproduct Precursors from Gaseous Waste Streams

Various industrial processes are a significant source of greenhouse gas emissions, particularly carbon oxides such as CO_2 and CO. Utilizing these streams as a feedstock for biofuel and bioproduct precursors could reduce GHG emissions both directly and indirectly via displacement of virgin petroleum. Algae and other crops do capture and use CO_2.but photosynthesis is an inefficient method for reducing oxidized carbon. Thus, the DOE is interested in non-photosynthetic means to directly reduce industrial waste gas streams with concentrated carbon oxides and to convert those carbon oxides to organic biofuel and bioproduct precursors.

While this subtopic is not constrained in terms of conversion technologies, the prospect of excess renewable electricity providing the reducing power needed to capture and use carbon oxides from waste gases is an intriguing possibility. The intermittent nature of renewable sources such as wind and solar can create imbalances between electricity supply and demand, which creates an opportunity to store surplus energy in chemical bonds.

There are numerous articles in the literature on inorganic electrochemical conversion of CO_2 to organic carbon species (1-4), some of which report promising results under laboratory conditions. A similar situation prevails for microbial electrochemical strategies (5-7). However, challenges still remain in bringing these kinds of solutions to market at meaningful scales (2, 8-9). The DOE seeks grant applications for development and demonstration of non-photosynthetic technologies and processes that capture and use carbon oxides to generate biomass, organic chemical intermediates, value-added organic chemicals and/or organic fuels. The integrated system can employ any combination of electrochemical, thermochemical, catalytic or biocatalytic (whole cell or cell free) unit

processes to perform the non-photosynthetic conversion of inorganic carbon oxides into organic carbon species.

Other considerations include:

- Proposed systems must utilize gaseous waste streams that would otherwise be released to the atmosphere as the primary feedstock to produce fuels. Flue or other waste gases containing CO_2 and/or CO are the primary target.
- By Phase II, and preferably within Phase I, proposed projects should employ actual (rather than model or synthetic) waste streams as feedstocks.
- Successful applications will propose to develop and run pilot systems by the end of Phase II, at a relevant scale (e.g., 100–1,000 L reactor volume).
- Applications need to address the overall energy balance of the proposed system
- Successful applications will minimize the ratio of required energy inputs to the energy potential of proposed outputs.
- Carbon efficiency is another important metric. Applications will be evaluated on their probability of maximizing utilization of the carbon available in relevant resource streams.
- Proposals that use algae or any other organism or process that requires sunlight will be considered non-responsive.
- In all cases, the DOE is interested in projects that present the possibility of producing commercially relevant and economically competitive higher hydrocarbons from gaseous sources to displace petroleum. Examples include formic acid, butanol, 1,4-butanediol, and medium-chain fatty acids, such as succinic, muconic, and lactic acids. Proposals that strive to complete the conversion of relevant feedstocks to jet or diesel fuels by the end of phase II are particularly encouraged.
- Phase I proposals may assume the availability of renewable electrons. However, by the end of phase II, projects must complete preliminary life cycle assessments that make realistic assumptions about the sources of energy used in conversion.
- If an external source of hydrogen is part of the process, it must be renewable by the end of phase II. Hydrogen from natural gas may be used as a test material in the early stages, but the application must clearly articulate how renewable hydrogen will be supplied by the end of phase II.

Questions - contact Mark Philbrick, mark.philbrick@ee.doe.gov

b. Manipulation of Nanocellulose into High-Value Products

Nanocellulose materials have great potential for generating sustainable products that displace their existing counterparts or fulfill yet-unseen roles. The unique and variable properties of these materials, such as strength, elasticity, density [1], and ability to self-assemble, as well as their capacity to be functionalized (2) make nanocellulose a promising substance for a number of uses. Combined with the fact that these fibers are derived from the most plentiful polymer on the planet, it is obvious that there is the potential for a large market of high-value products derived from nanocellulose.

The range of potential applications of cellulose nanomaterials is substantial and provides an opportunity to develop new biobased products that complement the effort to establish a bioeconomy in which petroleum-based fuels and products are replaced with those derived from biomass. Depending on the extraction process the size, crystallinity and mechanical properties of nanocellulose fibers can vary greatly (3), implying that a wide variety of applications for the material are possible. Recent work has shown that applications as structural composites, insulation, membranes, filters, packaging materials, thickening agents, and electronics are possible from nanocellulose. The Department of Energy seeks grant applications for projects which use nanocellulose to create high-value products. Due to the wide range of nanocellulose applications, DoE is open to a variety of technologies and applications for this solicitation, however, a clear economic value to the nanocellulose-based product must be demonstrated.

Other items to consider are:

- The target product must be clearly described, including its production and final structural, chemical, and mechanical properties. Description also must include the specific characteristics of the nanocellulose required to produce the target product and a brief description of how that particular nanocellulose would be acquired or generated for the proposed work.
- Applicants must clearly describe the current market for the target product and/or its existing counterpart.
- Applications must quantify the advantage of using nanocellulose for the target application in comparison to conventional materials. This can include reductions in production cost or fossil carbon usage or it can be based on improved properties of the target product.

Questions - contact Ian Rowe, ian.rowe@ee.doe.gov

c. Energy- and Cost-Effective Generation of Nanocellulose

Lignocellulose is a complex matrix of varying ratios of hemicellulose, cellulose and lignin, depending on the type of biomass. Deconstruction and fractionation of biomass is required in order to untangle these components and is often accomplished via a chemical pretreatment step of varying severity, such as acid or alkaline exposure. The resulting solid fraction of biomass contains the majority of the crystalline and amorphous cellulose from the starting biomass, which can be hydrolyzed into C6 sugar monomers for further fermentation or chemical conversion. Alternatively, the cellulose stream can be converted into cellulose nanofibers (CNF), more commonly called nanocellulose. Nanocellulose has noteworthy thermal and mechanical properties and the potential to be used for a wide variety of applications such as polymer reinforcement, food packaging [1], 3D printing resins, adhesives, biocomposites [2], textiles, lightweight structural components, tissue implants [3], and foams [4].

A major challenge of generating high quantities of nanocellulose for these purposes is the difficulty and/or cost of depolymerizing the cellulose. This conversion commonly occurs through mechanical (sheering, grinding, crushing, etc.) chemical (oxidation and carboxymethylation) (5) or enzymatic treatments (6, 7). Given that cellulose is the most abundant polymer on the planet, the Department of Energy seeks grant applications concerning technologies utilizing this resource and generating nanocellulose from biomass with separation processes which are both energy and cost-effective. This subtopic is open to a wide range of conversion technologies, however applicants should focus on techniques which use cellulose derived from common biological deconstruction processes.

Other considerations are:

- The resulting nanocellulose fibers should be in the nanoscale range of ~1-100 nm.
- Applications must propose a procedure in which the remaining fractions of biomass are not rendered unusable and still have the potential to be hydrolyzed and upgraded (in the case of hemicellulose) or isolated for further applications (in the case of lignin).
- Applications must quantify how this process economically and energetically improves upon current cellulose treatment procedures.
- Applications must specifically indicate how this nanocellulose target will improve the economics of an existing biological conversion processes. This should be accomplished by demonstrating that the nanocellulose procedure will reduce the minimum fuel selling price (MFSP,$/GGE) in one of the BETO Low-Temperature Deconstruction design cases.

Questions - contact Ian Rowe, ian.rowe@ee.doe.gov

REFERENCES: Subtopic a:

1. Goncalves, M. R., Gomes, A., et al., 2013, Electrochemical Conversion of CO_2 to C_2 Hydrocarbons Using Different Ex Situ Copper Electrodeposits, Electrochimica Acta, Volume 102, Elsevier, p. 388-392. (http://www.sciencedirect.com/science/article/pii/S0013468613006506)

2. Jhong, H. R., Ma, S., et al., 2013, Electrochemical Conversion of CO_2 to Useful Chemicals: Current Status, Remaining Challenges, and Future Opportunities, Current Opinion in Chemical Engineering, Volume 2, Issue 2, Elsevier, p. 191-199. (http://www.scs.illinois.edu/kenis/Files/112_CurrOpChemE_CO2_challenges_n_opp_2013.pdf)

3. Gan, L., Ye, L., et al., 2016, Demonstration of Direct Conversion of CO_2/H_2O into Syngas in a Symmetrical Proton-Conducting Solid Oxide Electrolyzer, International Journal of Hydrogen Energy, Volume 41, Issue 2, p. 1170-1175. (http://www.sciencedirect.com/science/article/pii/S0360319915303293)

4. Kumar, B., Brian, J.P., et al., 2016, New Trends in the Development of Heterogeneous Catalysts for Electrochemical CO2 Reduction, Catalysis Today, Volume 270, p. 19-30. (https://www.researchgate.net/publication/295395950_New_trends_in_the_development_of_heterogeneous_catalysts_for_electrochemical_CO2_reduction)

5. Mohan, S. V., Velvizhi, G., et al., 2014, Microbial Catalyzed Electrochemical Systems: A Bio-Factory with Multi-Facet Applications, Bioresource Technology, Volume 165, p. 355-364. (https://www.researchgate.net/publication/262049999_Microbial_catalyzed_electrochemical_systems_A_bio-factory_with_multi-facet_applications)

6. Srikanth, S., Maesen, M., et al., 2014, Enzymatic Electrosynthesis of Formate Through CO_2 Sequestration/Reduction in a Bioelectrochemical System (BES), Bioresource Technology, Volume 165, p. 350-354. (https://www.researchgate.net/publication/260378039_Enzymatic_electrosynthesis_of_formate_through_CO2_sequestrationreduction_in_a_bioelectrochemical_system_BES)

7. Ueki, T., Nevin, K.P., et al., 2014, Converting Carbon Dioxide to Butyrate with an Engineered Strain of Clostridium ljungdahlii, Mbio, Volume 5, Issue 5. (http://mbio.asm.org/content/5/5/e01636-14.full)

8. Durst, J., Rudnev, A., et al., 2015, Electrochemical Reduction - A Critical View on Fundamentals, Materials and Applications, Chimia, Volume 69, Issue 12, p. 769-776. (https://www.ncbi.nlm.nih.gov/pubmed/26842328)

9. ElMekawy, A., Hegab, H., et al., 2016, Technological Advances in CO_2 Conversion Electro-Biorefinery: A Step Toward Commercialization, Bioresource Technology, Volume 215, p. 357-370. (https://www.researchgate.net/publication/296572808_Technological_advances_in_CO2_conversion_electro-biorefinery_A_step_toward_commercialization)

10. Durst, J., Rudnev, A., et al., 2015, Electrochemical CO2 Reduction-A Critical View on Fundimentals, Materials and Applications, Chimia, Volume 69, Issue 12, p. 769-776. (https://www.ncbi.nlm.nih.gov/pubmed/26842328)

11. ElMekawy, A., Hegab, H. M., et al., 2016, Technological Advances in CO_2 Conversion Electro-Biorefinery: A Step Toward Commercialization, Bioresource Technology, Volume 215, Elsevier Ltd., p. 357-370. (https://www.ncbi.nlm.nih.gov/pubmed/27020396)

12. Gan, L., Ye, L., et al., 2016, Demonstration of Direct Conversion of CO_2/H_2O Into Syngas in a Symmetrical Proton-Conducting Solid Oxide Electrolyzer, International Journal of Hydrogen Energy, Volume 41, Issue 2, Elsevier Ltd., p. 1170-1175. (http://www.sciencedirect.com/science/article/pii/S0360319915303293)

13. Goncalves, M. R., Gomes, A., et al., 2013, Electrochemical Conversion of CO_2 to C_2 Hydrocarbons Using Different Ex Situ Copper Electrodeposits, Electrochimica Acta, Volume 102, Elsevier Ltd., p. 388-392. (http://www.sciencedirect.com/science/article/pii/S0013468613006506)

14. Jhong, H. R., Ma, S. C., et al., 2013, Electrochemical Conversion of CO_2 to Useful Chemicals: Current Status, Remaining Challenges, and Future Opportunities, Current Opinion in Chemical Engineering, Volume 2, Issue 2, p. 191-199.

(https://experts.illinois.edu/en/publications/electrochemical-conversion-of-cosub2sub-to-useful-chemicals-curre)

15. Kumar, B., Brian, J. P., et al., 2016, New Trends in the Development of Heterogeneous Catalysts for Electrochemical CO_2 Reduction, Catalysis Today, Volume 270, Elsevier, p. 19-30. (http://www.sciencedirect.com/science/article/pii/S0920586116300876)

16. Mohan, S. V., Velvizhi, G., et al., 2014, Microbial Catalyzed Electrochemical Systems: A Bio-Factory with Multi-Facet Applications, Bioresource Technology, Volume 165, p. 355-364. (https://www.ncbi.nlm.nih.gov/pubmed/24791713)

17. Srikanth, S., Maesen, M., et al, 2014, Enzymatic Electrosynthesis of Formate Through CO_2 Sequestration/Reduction in a Bioelectrochemical System (BES), Bioresource Technology, Volume 165, p. 350-354. (https://www.researchgate.net/publication/260378039_Enzymatic_electrosynthesis_of_formate_through_CO2_sequestrationreduction_in_a_bioelectrochemical_system_BES)

18. ElMekawy, A., Hegab, H. M., et al., 2016, Technological Advances in CO_2 Conversion Electro-Biorefinery: A Step Toward Commercialization, Bioresource Technology, Volume 215, p. 357-370. (https://www.researchgate.net/publication/260378039_Enzymatic_electrosynthesis_of_formate_through_CO2_sequestrationreduction_in_a_bioelectrochemical_system_BES)

19. Gan, L., Ye, L., et al., 2016, Demonstration of Direct Conversion of CO_2/H_2O into Syngas in a Symmetrical Proton-Conducting Solid Oxide Electrolyzer, International Journal of Hydrogen Energy, Volume 41, Issue 2, p. 1170-1175. (http://www.sciencedirect.com/science/article/pii/S0360319915303293)

20. Goncalves, M. R., Gomes, A., et al., 2013, Electrochemical Conversion of CO_2 to C_2 Hydrocarbons Using Different Ex Situ Copper Electrodeposits, Electrochimica Acta, Volume 102, p. 388-392. (http://www.sciencedirect.com/science/article/pii/S0013468613006506)

21. Jhong, H. R., Ma, S. C., et al., 2013, Electrochemical Conversion of CO_2 to Useful Chemicals: Current Status, Remaining Challenges, and Future Opportunities, Current Opinion in Chemical Engineering, Volume 2, Issue 2, p. 191-199. (http://www.scs.illinois.edu/kenis/Files/112_CurrOpChemE_CO2_challenges_n_opp_2013.pdf)

22. Kumar, B., Brian, J. P., et al., 2016, New Trends in the Development of Heterogeneous Catalysts for Electrochemical CO2 Reduction, Catalysis Today, Volume 270, p. 19-30. (http://www.sciencedirect.com/science/article/pii/S0920586116300876)

23. Mohan, S. V., Velvizhi, G., et al., 2014, Microbial Catalyzed Electrochemical Systems: A Bio-Factory With Multi-Facet Applications, Bioresource Technology, Volume 165, p. 355-364. (https://www.researchgate.net/publication/262049999_Microbial_catalyzed_electrochemical_systems_A_bio-factory_with_multi-facet_applications)

24. Srikanth, S., Maesen, M., et al., 2014, Enzymatic Electrosynthesis of Formate Through CO_2 Sequestration/Reduction in a Bioelectrochemical System (BES), Bioresource Technology, Volume 165, p. 350-354. (https://www.researchgate.net/publication/260378039_Enzymatic_electrosynthesis_of_formate_through_CO2_sequestrationreduction_in_a_bioelectrochemical_system_BES)

25. Ueki, T., Nevin, K. P., et al., 2014, Converting Carbon Dioxide to Butyrate with an Engineered Strain of Clostridium ljungdahlii, Mbio, Volume 5, Issue 5. (http://mbio.asm.org/content/5/5/e01636-14.full)

REFERENCES: Subtopic b:

1. Klemm D., Kramer F., Moritz S., et al., 2011, Nanocelluloses: A New Family of Nature-Based Materials, Angewandte Chemie (International Ed. In English), Volume 50, Issue 24, p. 5438-66. (https://www.ncbi.nlm.nih.gov/pubmed/21598362)

2. Habibi, Y., Lucia, L.A., and Rojas, O.J., 2010, Cellulose Nanocrystals: Chemistry, Self-Assembly, and Applications, Chemical Reviews, Volume 110, Issue 6, p. 3479-3500. (http://www4.ncsu.edu/~ojrojas/PDF/2010_2.pdf)

3. Börjesson, M., and Westman, G., 2015, Crystalline Nanocellulose — Preparation, Modification, and Properties, Cellulose – Fundamental Aspects and Current Trends, DOI: 10.5772/61899. (http://www.intechopen.com/books/cellulose-fundamental-aspects-and-current-trends/crystalline-nanocellulose-preparation-modification-and-properties)

REFERENCES: Subtopic c:

1. Li, Fei, Mascheroni, E., and Piergiovanni, L., 2015, The Potential of NanoCellulose in the Packaging Field: A Review, Packaging Technology and Science, Volume 28, Issue 6, p. 475-(508. http://onlinelibrary.wiley.com/doi/10.1002/pts.2121/abstract)

2. Lee, K.Y., Aitomäki, Y., Berglund, L.A., et al., 2014, On the Use of Nanocellulose As Reinforcement in Polymer Matrix Composites, Composites Science and Technology, Volume 105, p. 15-27. (http://www.sciencedirect.com/science/article/pii/S0266353814003236)

3. Leea, K.Y., Aitomäkib, Y., Berglundc, L.A., et al.,, On the Use of Nanocellulose as Reinforcement in Polymer Matrix Composites, Composites Science and Technology, Volume 105, p. 15-27. (http://www.sciencedirect.com/science/article/pii/S0266353814003236)

4. Jorfi, M., and Foster, E.J., 2015, Recent Advances in Nanocellulose for Biomedical Applications, Journal of Applied Polymer Science, Volume 132, Issue 14. (http://onlinelibrary.wiley.com/doi/10.1002/app.41719/abstract)

5. Faruk, O., Mohini, S., Farnood, R., et al., 2014, Development of Lignin and Nanocellulose Enhanced Bio PU Foams for Automotive Parts, Journal of Polymers and the Environment, Volume 22, Issue 3, p. 279-288. (http://link.springer.com/article/10.1007/s10924-013-0631-x)

6. Bharimalla, A.K., Deshmukh, S.P., Patil, P.G., and Vigneshwaran, N., 2015, Energy Efficient Manufacturing of Nanocellulose by Chemo- and Bio-Mechanical Processes: A Review, World Journal of Nano Science and Engineering, Volume 5, Issue 4, p. 204-212. (http://file.scirp.org/pdf/WJNSE_2015122911475968.pdf)

7. Jonoobi, M., Oladi, R., Davoudpour, Y., et al., 2015, Different Preparation Methods and Properties of Nanostructured Cellulose from Various Natural Resources and Residues: A Review, Cellulose, Volume 22, Issue 2, p. 935-969. (http://link.springer.com/article/10.1007/s10570-015-0551-0)

8. Brinchi, L., Cotana, F., Fortunati, E., and Kenny, J.M., 2013, Production of Nanocrystalline Cellulose from Lignocellulosic Biomass: Technology and Applications, Carbohydrate Polymers, Volume 94, Issue 1, p. 154-169. (http://www.brimee.eu/documents/28616/28897/Production+of+nanocrystalline+cellulose+from+lignocellulosic+biomass+-+Technology+and+applications.pdf/c92123c9-049a-4d14-b1db-72408fa43385;jsessionid=6cebcaec9ccd24f9984d0ea185c8?version=1.0)

10. BUILDINGS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

DOE's Building Technologies Office (BTO) advances building energy performance through the development and promotion of efficient, affordable, and high impact technologies, systems, and practices. BTO's 2020 goal is to reduce buildings' energy use by 30%, compared to 2010 "Energy Star" technologies. To secure these savings, research, development, demonstration, and deployment of next-generation building technologies in both the commercial and residential buildings sector are needed to advance building systems and components that are cost-competitive in the market.

Energy efficient lighting has enormous potential to conserve energy and enhance the quality of our commercial, industrial and residential building inventory. Electric lighting now consumes ~1/10th of the primary energy delivered annually in the U.S., representing ~22% of the electricity produced. Highly insulating windows have the potential for substantial energy savings relative to existing windows, which typically possess R-values ranging from R-1 (single glass) to R-3 (double glazing with low-E) and R-4 (triple or quadruple glazing). BTO internal analysis shows that the technical potential of R-10 windows, for example, is two quads by 2030. BTO estimates that improvements in the opaque portions of building envelopes (walls, roofs, foundation, and infiltration) have the technical potential to save over 4 quads by 2030, over half of it from residential buildings. However, market adoption of best in class envelope systems is slowed by real and perceived risks related to Indoor Air Quality (IAQ) and comfort in tighter, better insulated homes. Cost competitive technologies that reliably improve the IAQ and comfort performance of modern homes are needed to enable further advancement in

residential building envelope energy performance. BTO is dedicated to promoting the widespread and effective use of these technologies to meet its R&D goals.

BTO is collaborating with other offices within the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) on two joint topics.

GEOTHERMAL & BUILDINGS Joint Topic on Geothermal Heat Pumps
The Geothermal Technologies Office (GTO) and Buildings Technologies Office (BTO) collaborate to seek the development and commercialization of innovations that will reduce the cost and/or improve performance of ground-loops GHP systems.
BUILDINGS & SOLAR Joint Topic on Building Energy Storage Management
The Buildings Technologies Office (BTO) and Solar Energy Technology Office (SETO) seek to collaborate in the development and commercialization of software innovations that will reduce the cost and improve the value and performance of battery energy storage.

Grant applications are sought in the following subtopics:

a. Innovations to Improve Window Cost and Performance

The US DOE is interested in the development of low-cost, highly insulated windows in two ranges of insulation performance: 1) windows with NFRC U-values in the range of 0.20 to 0.14 [Btu/hr-ft2-F] (R5 to R7) and 2) windows with NFRC U values in the range of 0.13 to 0.10 [Btu/hr-ft2-F] (R8 to R10) that are marketable based on cost, visible light transmission, weight, and ease of installation. We also have interest in lower cost dynamic glazings that allow for significant modulation of the solar heat gain coefficient (SHGC), from 0.10 in the switched or darkened state to 0.50 in the clear state. In pursuit of these objectives, DOE is interested in fundamental science and technology developments that can contribute significantly toward the achievement of these goals, such as the following:

- Low-cost, fast, and efficient krypton gas insulating glass unit filling;
- Window spacers that allow for installation of non-structural inter-panes or inter-layers to enable multiple cavity insulated glass units without increasing gas leakage potential;
- Low-cost and highly reliable glass to metal bonding for use in vacuum glazings including possible overall vacuum glass edge sealing that can withstand large thermal expansion structural loads and that allows for ease of glass sizing without complex customized molds or specialized glass processing;
- Low-cost and easily installed vacuum glass standoffs that minimize thermal conductions, compression stress points, and have minimal degradation of view through a vacuum glazing;
- Coating methods for dynamic glass that has the potential to offer very high durability (e.g. high temperature, high UV, and optical dynamic cycling concurrently in accordance with a variety of ASTM test protocols) at very low cost (e.g potential to achieve $5 per sq ft price premium over typical double pane low-e insulated glass units);

- Dynamic glazing designs that through lower cost designs, and system level applications, have the potential to achieve a simple payback of less than five years.

Questions - contact Marc LaFrance, marc.lafrance@ee.doe.gov

b. Innovations in Solid-State Lighting for Buildings

An extraordinary transformation in energy efficient building illumination is underway fueled in part by EERE's long-term commitment to the advancement of energy efficient, environmentally responsible and high quality Solid-State Lighting (SSL) technology, products and applications. Traditional, legacy electric light sources and general illumination products are rapidly being replaced by new SSL technologies that are several times more energy efficient, contain far less hazardous, toxic or rare materials, and are inherently compatible with renewable energy sources and contemporary digital control topologies. Even with this unprecedented transformation in lighting that promises significant reduction in our national primary energy consumption, certain important opportunities remain that are well suited to technological innovation from domestic small business whose imagination and ability to rapidly respond to evolving market opportunities are a key part of the economic growth encouraged by the Department's SBIR-STTR program.

The focus of this technical subtopic is identification of nascent and niche opportunities that will leverage the tremendous power of SSL towards achieving the DOE's aggressive energy conservation goals in buildings. These business opportunities might include new, novel or innovation applications of emerging technology that can be used to produce a commercially viable intermediate SSL products or components, provide unparalleled opportunities for lighting control or connectivity or addresses a unique lighting opportunity where energy conservation can be complemented by other lighting-related impacts such as improvements to animal or horticultural growth, productivity, health and well-being. Examples of applicable SSL components might include advancements in power supply design that overcomes certain performance and efficiency limitations especially during dimming or incorporation of light management techniques that direct more light where required thereby reducing power consumption. SSL is uniquely compatible with digital controls and evolving flexible connections to the Internet of Things (IOT). Today, the lighting industry is just beginning to identify opportunities to leverage the unique command and control attributes of SSL in large volume applications. But there are many smaller opportunities in the building environment where the introduction of novel and imaginative new products can leverage the power of connectivity. These might be certain niche applications that are unattractive for a large manufacturer due to their small market potential but may be just the right sized opportunity for a small business or one with highly flexible design and manufacturing capability. There may also be opportunities to power SSL products completely off grid eliminating the cost and complexity of delivering power to remote or difficult locations and harvesting the power of advanced photovoltaic, control and storage technologies by crosscutting with related DOE EERE program objectives. Combining the performance and spectral properties unique to SSL with animal, horticultural or human

benefits is emerging as a potential high impact application whose value is just beginning to be realized. Applications that seek to combine the energy conservation and spectral benefits to commercial enterprises such as controlled environment agriculture or circadian regulation or other physiological effects are sought.

The above are suggested opportunities and examples but should not be considered as a restriction to other imaginative new and novel intermediate components, luminaires or intellectual property. This subtopic is therefore open to any new and innovative concept that fits generally into the mission of the DDOE SSL Program and that demonstrate some level of technical risk and commercial viability. Applications that reflect ideas that have already been demonstrated by the DOE or other Federal Agencies or investment mechanisms are not eligible. Proposals that seek to advance existing designs or products with improvements normally associated with commercial product evolution are similarly ineligible. Likewise, concepts that fail to demonstrate a viable pathway to commercial success and that represent the potential to make a lasting and positive impact on the evolution of energy efficient, high quality solid-state lighting will not be accepted. The key metric for judging responsiveness of all proposals will be the commercialization potential identified in the applications, quantitative comparison to existing products or components and technical risk retirement during Phase I.

All Letters of Intent will be carefully reviewed and should include the following elements: (1) provide sufficient technical detail, (2) seek to make proof of principle during Phase I leading to commercial viability following Phase II, and (3) represent truly new, novel and innovative solutions. Those failing to provide this information will be notified that they appear to be nonresponsive to this subtopic. The above descriptions highlight a few opportunities that are of special interest to the DOE and the SSL Program objectives and metrics are more completely described in the DOE Solid-State Lighting (SSL) program's comprehensive website: http://www1.eere.energy.gov/buildings/ssl/ There, many technical reports, roundtable summaries, program roadmaps and summaries of current and past SSL projects may be reviewed and downloaded.

Questions - contact James R. Brodrick, james.brodrick@hq.doe.gov

c. Innovations to Improve IAQ and Comfort Performance in Energy Efficient Residential Buildings

Since 1994, the rigor of the national energy code (IECC) has increased over 40% by applying high performance building envelope innovations proven with Building America research and demonstration. But, before substantial additional insulation and air-sealing requirements can be responsibly adopted into future advanced building energy codes and home energy upgrade programs, indoor air quality (IAQ) and comfort risks must be better managed by the housing industry.

Significant progress has been made, through research, demonstration, and development of ventilation equipment and standards. Building America Top Innovation Profiles highlight several of the most impactful residential IAQ technology and industry standard developments to date.

However, significant technology gaps remain in residential building comfort and IAQ control. Research and field-testing by Building America industry teams and others have advanced relevant building science knowledge, developed best practice guidance, identified common IAQ and comfort failures, and identified additional research and technology needed to help the industry reliably achieve optimal IAQ, comfort, and energy efficiency in modern houses. The Building America Research to Market Plan includes two roadmaps for addressing these challenges - the Optimal Ventilation and IAQ Solutions and Optimal Comfort Systems for Low-Load Homes - which summarize the state of the art in IAQ and comfort performance and control technologies, lay out specific objectives related to these challenges, and include extensive reference lists for each roadmap.

With this technical subtopic, BTO seeks to identify and encourage development of innovative technologies with the potential to improve IAQ and comfort in new and existing homes, without little or no energy penalty and very low incremental cost to builders and contractors. Preference will be given to technology solutions that are applicable to both new homes and the existing building stock. While modest feasibility studies are appropriate for Phase I funding, applications for this subtopics should be transitioning to manufacturing by Phase II to be considered for further funding. BTO strongly encourages applicants to include a strategy for obtaining manufacturing partners by the end of Phase 1 as a part of their commercialization plan.

Specifically, DOE is interested in the following IAQ and comfort control technology applications:

- Low-cost humidity control systems and solutions, particularly those that are integrated with central cooling and/or ventilation systems, and are cost competitive with current ERV technology;
- Low-cost, reliable add-on sensors and controls for improved operation and maintenance of existing HVAC systems, particularly those that enable system optimization and/or improve system reliability;
- Automated and/or assisted (i.e., “intelligent”) HVAC system commissioning tools, particularly those that address total system performance including distribution efficiency;
- Smart ventilation/IAQ systems (sensors, controls, hardware, software) that optimize IAQ and minimize energy penalties, based on indoor conditions (i.e., temperature, RH, pollutant levels), outdoor conditions (i.e., temperature, RH, and/or pollutant levels), occupancy, and other variables such as weather forecast data.

Questions - contact Eric Werling, eric.werling@ee.doe.gov

REFERENCES: Subtopic a:

1. Arasteh, Dariush K., Howdy Goudey, and Christian Kohler, 2008, Highly Insulating Glazing Systems Using Non-Structural Center Glazing Layers, In 2008 Annual ASHRAE Meeting, Salt Lake City, UT, 2008. (http://eetd.lbl.gov/sites/all/files/publications/611e.pdf)

2. Arasteh, D., Selkowitz, S., Apte, J., and Marc LaFrance, 2006, Zero Energy Windows, ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, 2006. (http://eetd.lbl.gov/sites/all/files/publications/60049.pdf)

REFERENCES: Subtopic b:

1. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2016, Solid-State Lighting Research & Development Plan. (http://energy.gov/eere/ssl/downloads/solid-state-lighting-2016-rd-plan)

2. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2016, DOE Solid-State Lighting Program: Modest Investments, Extraordinary Impacts. (http://energy.gov/eere/ssl/downloads/solid-state-lighting-program-overview-brochure)

3. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2014, DOE Joint Solid-State Lighting Roundtables on Science Challenges. (http://energy.gov/eere/ssl/downloads/doe-joint-solid-state-lighting-roundtables-science-challenges)

REFERENCES: Subtopic c:

1. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2015, Building America Program Research-to-Market Plan. (http://energy.gov/eere/buildings/downloads/building-america-program-research-market-plan)

2. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2014, Building America Top Innovation Profile: ASHRAE Standard 62.2. Ventilation and Acceptable Indoor Air Quality in Low-Rise Residentail Buildings. (http://energy.gov/eere/buildings/downloads/ashrae-standard-622-ventilation-and-acceptable-indoor-air-quality-low-rise)

3. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2013, Low-Cost Ventilation for Production Housing – Building America Top Innovation. (http://energy.gov/eere/buildings/downloads/building-america-top-innovations-hall-fame-profile-low-cost-ventilation)

4. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2013, Outside Air Ventilation Controller- Building America Top Innovation. (http://energy.gov/eere/buildings/downloads/building-america-top-innovations-hall-fame-profile-outside-air-ventilation

11. FUEL CELLS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office (FCTO) (http://www1.eere.energy.gov/hydrogenandfuelcells) works in partnership with industry (including small businesses), academia, and DOE's national laboratories to establish fuel cell and hydrogen energy technologies as economically competitive contributors to U.S. transportation needs. A roadmap for the development of fuel cell and hydrogen technologies that guides FCTO investments aimed at lowering the related risks and costs can be found here: http://energy.gov/eere/fuelcells/downloads/fuel-cell-technologies-office-multi-year-research-development-and-22 .

The office's portfolio focuses on both fuel cell research and development (R&D) and hydrogen fuel R&D, with an emphasis on renewable pathways, delivery, and storage of hydrogen, to meet cost and performance goals. Near term efforts in real-world demonstration and validation help to accelerate market growth and provide critical feedback for future R&D. The portfolio also addresses a number of non-technical factors, such as user confidence, ease of financing, the availability of codes and standards, and helping to enable the establishment of a refueling infrastructure, particularly for fuel cell electric vehicles.

Applications may be submitted to any one of the subtopics listed below but all applications must:

- Propose a tightly structured program which includes technical milestones that demonstrate clear progress, are aggressive but achievable, and are quantitative;
- Include projections for price and/or performance improvements that are tied to a baseline (i.e. Multi-Year Program Plan (MYPP) or Roadmap targets and/or state of the art products or practices);
- Explicitly and thoroughly differentiate the proposed innovation with respect to existing commercially available products or solutions;
- Include a preliminary cost analysis;
- Justify all performance claims with theoretical predictions and/or relevant experimental data

a. Innovative Materials and/or Technologies for Bipolar Plates for PEM Fuel Cell

Bipolar plates account for approximately 30% of the stack cost and 60% of the stack weight in polymer electrolyte membrane (PEM) fuel cells [1]. This subtopic solicits applications that directly or indirectly address the cost and weight reduction of PEM fuel cell stacks. Applications should focus on innovative materials, manufacturing processes and/or designs of bipolar plates. Projects should aim to achieve one or more of the following:

- Development and testing of innovative materials with superior performance, high stability and corrosion resistance with reduced cost.
- Development of innovative designs to improve thermal and flow management that could lead to lowering balance of plant requirements.

All proposed projects must demonstrate potential to meet or exceed DOE's 2020 bipolar plate technical targets [2] as well as the cost target of $3/kW. To achieve the targets, advancements in manufacturing processes that result in lower production cost, accelerating the manufacturing and assembly time, and in enhanced bipolar plate durability should be considered. Manufacturing processes leading to lighter, thinner, more durable and easier to fabricate bipolar plates can include but are not limited to sealing, joining, and forming.

All proposed designs should be suitable for transportation applications and contribute to meeting DOE's stack technical targets [2]. This subtopic is looking for completely innovative/out-of-the-box approaches and does not encourage the approaches that have already been funded by DOE.

Questions - contact Bahman Habibzadeh, bahman.habibzadeh@ee.doe.gov

b. Liquid Organic Hydrogen Carriers (LOHC)

Liquid organic hydrogen carriers (LOHCs) are an alternative to gaseous tube trailers and liquid tankers for the delivery of hydrogen. Carriers are advantageous because of their ability to store hydrogen at higher volumetric density than compressed gas, their ability to be stored at ambient temperatures without boil-off losses, and their compatibility with the existing petroleum infrastructure [1]. These advantages enhance the potential of carriers to leverage stranded renewable energy resources for cost-effective delivery of hydrogen produced in remote locations. [2]

To date, LOHCs that have been developed and demonstrated at lab or pilot scales are not up to the challenge of optimizing several properties simultaneously. These key properties include hydrogen capacity, hydrogenation/dehydrogenation rates and energy requirements, reversibility, toxicology, and compatibility with catalysts. Many approaches have been explored to improve LOHC performance, such as heteroatom substitutions to lower the temperature of hydrogen release [3], increasing the size of aromatic hydrocarbons being used to lower the enthalpy of dehydrogenation [4], or introducing bulky functional groups that improve reversibility [5].Applications are sought for the development and demonstration of a reversible LOHC that is non-toxic and enables hydrogen delivery to a refueling station or centralized terminal at <$5.00/kg, including the cost of the carrier itself, cost of the catalyst, and energy consumption associated with hydrogenation/dehydrogenation. Ammonia-based carriers are specifically not of interest, due to the significant R&D that has been conducted in this area already [6].

Phase I will be for the use of computational chemistry to design a LOHC that is predicted to meet the technical characteristics defined above. Applicants should specify the catalyst that will be used for hydrogenation/dehydrogenation, describe the computational/experimental approach being chosen to develop a carrier, and project the hydrogen capacity, approximate enthalpies required for hydrogenation/dehydrogenation, and approximate cost of the carrier being developed. Follow-on Phase II funding will be for the scale up of the selected LOHC to > 10 g and demonstration of hydrogenation/dehydrogenation, with characterization of key parameters, including: hydrogen capacity, enthalpies and kinetics of hydrogenation/dehydrogenation, formation of intermediate products, purity of hydrogen, reversibility over time, and impact on catalyst performance over time.

Questions - contact Neha Rustagi, Neha.Rustagi@EE.Doe.Gov

c. Emergency Hydrogen Refuelers

Fuel Cell Electric Vehicles (FCEVs) are now commercially available in certain parts of the U.S. and other countries of the world. The utility of FCEVs is limited by the installation of hydrogen fueling stations. Even though current commercial FCEVs have driving ranges of about 300 miles, due to the sparsity of hydrogen fueling stations in the early years of FCEV commercialization, it is expected that many FCEV drivers will experience range anxiety. The California Fuel Cell Partnership's hydrogen stations website lists a total of 41 retail hydrogen fueling station open or expected to be opened in the state by the second quarter of 2017 [1]. Based on feedback from stakeholders, one way to alleviate range anxiety is to provide drivers with an "emergency hydrogen refueler" capable of providing sufficient hydrogen for them to drive to the nearest hydrogen fueling station.

Applications are sought for the development of two types of emergency hydrogen refuelers:

- Roadside assistance – portable emergency hydrogen refuelers to be carried on roadside assistance vehicles and capable of providing hydrogen to at least 3 stranded vehicles before needing to be recharged;
- Personal devices – portable emergency hydrogen refuelers that can be carried onboard the FCEV, such as in the trunk, easily handled by the driver and able to provide hydrogen to at least one stranded vehicle.

Emergency hydrogen refuelers must provide a high level of safety under both of the above use and storage conditions. The devices must be able to store hydrogen for extended periods of time without loss of hydrogen. They must also be capable of connecting to FCEVs and delivering hydrogen into the onboard hydrogen storage system on demand. Emergency hydrogen refuelers for use on roadside assistance vehicles should be rechargeable, whereas personal emergency hydrogen refuelers may be either rechargeable or one-time use devices.

Phase I of this effort is expected to include an in-depth analysis that includes storage technology choice, including the proposed material to be used for material-based systems, preliminary engineering designs and projected system costs. Justification for the amount of hydrogen stored should include the number of vehicles to be serviced between device recharging and the driving distance enabled. For reference, the rated fuel economy of available FCEVs is provided on the fueleconomy.gov website [2]. Projections of the system mass and volume should be provided. [2] The phase I effort should identify the key technology gaps and engineering requirements that need to be addressed for successful development of the proposed device. Identification of additional applications where the proposed device could be used and provide benefit in enabling commercialization of hydrogen fuel cell technologies will further strengthen the proposal. No material or hardware development should be proposed as part of the Phase I effort.

Phase II of the effort should focus on development of the proposed emergency hydrogen refueler, addressing the key technology gaps and engineering requirements identified in phase I. Hardware development, testing, and demonstration is expected to be included in the phase II effort. Either sub-scale system or full scale systems may be proposed as appropriate. Identification of commercialization strategies and a market analysis should be included in the Phase II application. Identification of potential commercialization partners, with indication of commitment, also should be included in the Phase II proposals.

Questions - contact Ned Stetson, Ned.Stetson@ee.doe.gov

REFERENCES: Subtopic a:

1. Richards, J., and Schmidt, K., 2011, Review – Metallic Bipolar Plates and Their Usage in Energy Conversion Systems, Alloy Steel - Properties and Use, Dr. Eduardo Valencia Morales (Ed.), InTech, p. 24, ISBN: 978-953-307-484-9. (http://www.intechopen.com/books/alloy-steel-properties-and-use/review-metallicbipolar-plates-and-their-usage-in-energy-conversion-systems)

2. U.S. Department of Energy, 2016, Fuel Cells Section, Multi-Year Research, Development, and Demonstration Plan. ,Table 3.4.8 Technical Targets: Bipolar Plates for Transportation Applications on page 3.4-22 (http://energy.gov/sites/prod/files/2016/06/f32/fcto_myrdd_fuel_cells_0.pdf)

REFERENCES: Subtopic b:

1. Arlt, W., Teichmann, D., Wasserscheid, P., 2012, Liquid Organic Hydrogen Carriers as an efficient Vector for the transport and Storage of renewable Energy, International Journal of Hydrogen Energy, Volume 37, Issue 23, p. 18118-18132. (http://www.sciencedirect.com/science/article/pii/S036031991201868X

2. Arlt, W., Teichmann, D., Wasserscheid, P., et al., 2016, Transport and Storage of Hydrogen Via Liquid Organic Hydrogen Carrier (LOHC) Systems, Hydrogen Science and Engineering: Materials, Processes, Systems and Technology. (http://onlinelibrary.wiley.com/doi/10.1002/9783527674268.ch33/pdf)

3. 2012, Design and Development of New Carbon-based Sorbent Systems for an Effective Containment of Hydrogen, DOE Award Final Report, p. 267. (http://www.osti.gov/scitech/servlets/purl/1039432)

4. He, T., Pei, Q., and Chen, P., 2015, Liquid Organic Hydrogen Carriers, Journal of Energy Chemistry, Volume 119, Issue 47. (http://www.imide.dicp.ac.cn/articals/2015/He%20Teng%20Liquid%20organic%20hydrogen%20carriers.pdf)

5. DOE Hydrogen and Fuel Cells Program, 2014, Annual Progress Report, IV.E.1 Novel Carbon©-Boron(B)-Nitrogen(N)-Containing H2 Storage Materials. (https://www.hydrogen.energy.gov/pdfs/progress14/iv_e_1_liu_2014.pdf)

6. The Chemical Hydrogen Storage Ceneter of Excellence Coordinating Council, 2008, Chemical Hydrogen Storage Center of Excellence FY2008 Second Quarter Milestone Report, Down Select Report of Chemical Hydrogen Storage Materials, Catalysts, and Spent Fuel Regeneration Processes, p.34. (http://energy.gov/sites/prod/files/2014/03/f10/chs_coe_down_select.pdf)

REFERENCES: Subtopic c:

1. California Fuel Cell Partnership, Station Map. (http://cafcp.org/stationmap)

2. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, Compare Fuel Cell Vehicles. (http://www.fueleconomy.gov/feg/fcv_sbs.shtml)

12. GEOTHERMAL

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The heat energy from the earth represents a nearly inexhaustible and underutilized domestic resource. The Office of Energy Efficiency and Renewable Energy's Geothermal Technologies Office (GTO) (www1.eere.energy.gov/geothermal/) works in partnership with industry, academia, and DOE's National Laboratories to establish geothermal energy as an economically competitive option for renewable energy in the United States. Current the U.S. has nearly 3.6 gigawatts (GW) of installed geothermal capacity, while Enhanced Geothermal Systems (EGS) potentially enables access to a vast additional potential of more than 100 GW of new geothermal energy.

Enhanced Geothermal Systems (EGS) are engineered reservoirs, created where there is hot rock but little to no natural permeability or fluid saturation present in the subsurface. In 2013, GTO outlined the underlying technology needs that will guide research and ultimately determine commercial success for EGS in a strategic roadmap which traces the Energy Department's investments, past and present, and ties them to these needs to guide future research. GTO's

flagship initiative in EGS is the Frontier Observatory for Research in Geothermal Energy (FORGE).

Grant applications are sought in the following subtopic:

a. Innovations that Enable Commercial Deployment of Enhanced Geothermal Systems

The Geothermal Technologies Office seek the development and commercialization of innovations that will enable cost-competitive deployment of EGS-based electricity generation in the U.S. We are interested in a broad range of innovations, as described in GTO's 2013 EGS Roadmap. Innovations of interest can be in software, which may include, but are not limited to, models and algorithms, such as real-time joint inversion or multicomponent fully-coupled geomechanical models. Other innovations of interest can be in hardware, which may include, but are not limited to, tools and materials, such as zonal isolation tools, down-hole sensors, packers, or diverters. Specifically not of interest in this topic area is the development of new tracer materials to include synthetic or naturally-occurring chemicals that are used determine fluid path and velocity within a reservoir. (Other innovations that make use of tracers are acceptable.)

As part of their proposals for this topic, applicants should estimate the potential improvements over the state of the art using metrics relevant to their innovation. GTO is seeking improvements that will lower the Levelized Cost of Energy to 6¢/kWh for EGS, which can be modeled using the Geothermal Electricity Technology Evaluation (GETEM) model.

Applicants should also provide their anticipated outcomes of Phase I as well as a path to phase up to potential Phase II follow on work and potential outcomes of Phase II. Proposals that include realistic scopes that would have them prepared for a field demonstration by the end of a Phase II will be given favorable consideration.

Questions - contact Josh Mengers, joshua.mengers@ee.doe.gov

REFERENCES: Subtopic a:

1. Ziagos, et al., 2013, A Technology Roadmap for Strategic Development of Enhanced Geothermal Systems, Proceedings, Thirty-Eighth Workshop on Geothermal Reservoir Engineering, Stanford, California, p. 24. (http://www1.eere.energy.gov/geothermal/pdfs/stanford_egs_technical_roadmap2013.pdf)

2. U.S. Department of Energy, Frontier Observatory for Research in Geothermal Energy (FORGE), Homepage. (http://energy.gov/eere/forge/forge-home)

3. U.S. Department of Energy, Geothermal Electricity Technology Evaluation (GETEM) model (http://energy.gov/eere/geothermal/geothermal-electricity-technology-evaluation-model)

see also joint Geothermal-Buildings Topic on Geothermal Heat Pumps.

13. SOLAR

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Office of Energy Efficiency and Renewable Energy's Solar Energy Technologies Office sponsors the SunShot Initiative (SunShot) (http://energy.gov/eere/sunshot/sunshot-initiative). SETO is working in partnership with industry, academia, national laboratories, and other stakeholders to achieve subsidy-free, cost-competitive solar power by 2020. The potential pathways, barriers, and implications of achieving the SunShot Initiative price reduction targets and resulting market penetration levels are examined in the SunShot Vision Study (http://energy.gov/eere/sunshot/sunshot-vision-study).

Applications may be submitted to any one of the categories listed below but all applications must:

- Propose a tightly structured program which includes technical milestones that demonstrate clear progress, are aggressive but achievable, and are quantitative;
- Include projections for price and/or performance improvements that are tied to a baseline (i.e. SunShot targets and/or state of the art products or practices);
- Explicitly and thoroughly differentiate the proposed innovation with respect to existing commercially available products or solutions;
- Include a preliminary cost analysis;
- Justify all performance claims with theoretical predictions and/or relevant experimental data

SETO is collaborating with other offices within the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) on one joint topic. More information can be found following the link below.

BUILDINGS and SOLAR Joint Topic on Commercial Buildings Energy Storage
Software Innovations for monitoring and control of battery energy storage in commercial and industrial buildings

In this Solar Topic, SETO seeks applications for the development of innovative and impactful technologies in the areas of:

a. Next Generation CSP Components For High Temperature Molten Chloride Salt Development

The next generation of Concentrating Solar Power (CSP) systems is expected to operate at temperatures above 700°C to achieve high thermal-to-electric efficiency and enable cost competitiveness with conventional methods of electric power generation. To date, SETO has identified molten chloride salts (for example, a eutectic mixture of KCl-$MgCl_2$, among other possible compositions) as a highly promising heat transfer fluid (HTF) and thermal energy storage (TES) media capable of operating between 550°C and 750°C. The high working temperatures and corrosive properties of these salts represent aggressive environments for CSP system components. This subtopic is focused on RD&D leading to demonstrating major subcomponents (i.e. solar concentrators, receivers, thermal energy storage systems, and power cycles) that can operate at high efficiency and low-cost under these conditions. The development of the next generation of components will require demonstration in a fully integrated facility at a commercially relevant scale. For this purpose, the DOE is seeking proposals that involve development of the following aspects of the molten salt system:

1. Impellers for molten salt pumps require materials and manufacturing techniques that are far less susceptible to corrosion and blade tip erosion than current technologies
2. Seals and bearings must be redesigned to perform robustly and reliably for this high temperature corrosive environment. Bearings in particular must be impervious to salt migration and freezing of rotating assemblies.
3. Molten chloride salt tanks for thermal energy storage containment costs must be reduced; For example, use of high nickel content alloys should be minimized or eliminated—especially for large tanks.
4. Systems to remove O_2 and H_2O in high temperature molten salt such as gas bubbling, gas sparging or chemical means to reduce chloride salt corrosion.
5. Systems to monitor O_2 and H_2O at parts per million levels are needed for larger scale testing and reliability.

Questions - contact solar.sbir@ee.doe.gov

b. CSP Operation and Maintenance (O&M) Innovation

Existing CSP installed capacity in the U.S. is more than 1 GW and growing worldwide. Improvements in O&M practices to assure performance at nameplate ratings are desired. Advances are sought in

1. Detection and correction of heliostat aiming and mirror canting that is rapid, accurate and cost effective

Questions - contact solar.sbir@ee.doe.gov

c. Photovoltaic Performance and Reliability Tools And Characterization Methods

For all sized PV system sizes, primary drivers of the levelized cost of photovoltaic (PV) electricity and investor return on investment, are the lifetime and reliability of system components. The reliability of a given component is set on the manufacturing floor and extends through its entire deployed lifetime. In order to ensure proper function over the entire lifecycle of a deployed system, applications are sought in:

1. Methods for detailed active monitoring of PV systems from small residential to large utility scale. Metrology and characterization tools to advance efficiency and reliability of fielded PV systems.
2. Hardware and/or software tools to facilitate operations and management of PV systems.
3. Areas of interest include:
   (1) Technology- and manufacturer-agnostic detection hardware or software tools capable of identifying, locating, and/or diagnosing the cause of underperforming modules and system hardware within a given array;
   (2) Tools and procedures for automating or streamlining the identification of maintenance events, defective part replacement, and other corrective procedures that will maximize the long term value of the array;
   (3) Advancing and developing essential in-line metrology tools connecting to device and module performance/reliability;
   (4) Characterization tools for understanding device and module performance and degradation consistently connecting to the device and module behavior. In addition, methods or tools developed for should focus on minimizing the capital cost of the product to have a minimal impact on project or product return on investment

Questions - contact solar.sbir@ee.doe.gov

14. VEHICLES

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

EERE's Vehicle Technologies Office (VTO) (www1.eere.energy.gov/vehiclesandfuels/) focuses on reducing the cost and improving the performance of vehicle technologies that can reduce petroleum dependency, including advanced batteries, electric traction drive systems, lightweight materials, advanced combustion engines, and advanced fuels and lubricants. VTO supports the development and deployment of advanced vehicle technologies, including advances in electric vehicles, engine efficiency, and lightweight materials. Since 2008, the Department of Energy has reduced the costs of producing electric vehicle batteries by more than 50%. DOE has also pioneered improved combustion engines that have saved billions of gallons of petroleum fuel, while making diesel vehicles as clean as gasoline-fueled vehicles.

Applications that duplicate research already in progress will not be funded; all submissions therefore should clearly explain how the proposed work differs from other work in the field.

Applications may be submitted to any one of the subtopics listed below but all applications must:

- Propose a tightly structured program which includes technical milestones that demonstrate clear progress, are aggressive but achievable, and are quantitative;
- Include projections for price and/or performance improvements that are tied to a baseline (i.e. Multi-Year Program Plan (MYPP) or Roadmap targets and/or state of the art products or practices);
- Explicitly and thoroughly differentiate the proposed innovation with respect to existing commercially available products or solutions;
- Include a preliminary cost analysis;
- Justify all performance claims with theoretical predictions and/or relevant experimental data

Grant applications are sought in the following subtopics:

a. Electric Drive Vehicle Batteries

Applications are sought to develop electrochemical energy storage technologies that support commercialization of micro, mild, and full HEVs, PHEVs, and EVs. Some specific improvements of interest include the following: new low-cost materials; high voltage and high temperature non-carbonate electrolytes; improvements in manufacturing processes – specifically the production of mixed metal oxide cathode materials through the elimination or optimization of the calcination step to reduce cost and improve throughput, speed, or yield; novel SEI stabilization techniques for silicon anodes; improved cell/pack design minimizing inactive material; significant improvement in specific energy (Wh/kg) or energy density (Wh/L); and improved safety. Applications must clearly demonstrate how they advance the current state of the art and meet the relevant performance metrics listed at www.uscar.org/guest/article_view.php?articles_id=85.

When appropriate, the technology should be evaluated in accordance with applicable test procedures or recommended practices as published by the Department of Energy (DOE) and the U.S Advanced Battery Consortium (USABC). These test procedures can be found at www.uscar.org/guest/article_view.php?articles_id=86. Phase I feasibility studies must be evaluated in full cells (not half-cells) greater than 200mAh in size while Phase II technologies should be demonstrated in full cells greater than 2Ah. Applications will be deemed non-responsive if the proposed technology is high cost; requires substantial infrastructure investments or industry standardization to be commercially viable; and/or cannot accept high power recharge pulses from regenerative breaking or has other characteristics that prohibit market penetration. Applications deemed to be duplicative of research that is already in progress or similar to applications already reviewed this year will not be funded;

therefore, all submissions should clearly explain how the proposed work differs from other work in the field.

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

b. SiC Device Qualification for Electric Drive Vehicle Power Electronics

Power electronic inverters are essential for electric drive vehicle operation, and the Vehicle Technologies Office (VTO) has established cost and performance targets that need to be met so that these vehicles can decouple personal mobility from oil, cut pollution and help build a 21st Century American automotive industry that will lead the world. Specifically, inverter R&D targets and research pathways have been outlined by DOE in both the U.S. DRIVE partnership Electrical and Electronics Technical Team Roadmap (http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/eett_roadmap_june2013.pdf) and EV Everywhere Blueprint (http://energy.gov/sites/prod/files/2014/02/f8/eveverywhere_blueprint.pdf). Both of these technical documents specifically address the performance benefits of Wide Band Gap (WBG) semiconductors, but their current high cost is a barrier to high volume automotive adoption.

With large area (> 150 mm, or 6") Silion Carbide (SiC) epitaxial wafer availability from a large number of qualified suppliers, the SiC device industry is approaching the state of the cost-competitive silicon (Si) power device industry, where the cost of fabrication is the primary driver for device cost, and their high device yield allows for a low overall cost of devices.

Vehicle inverters can take advantage of these SiC epitaxial wafers with SiC devices that offer significantly smaller on-state resistance as compared to current Si switches and enable power per area increases greater than 10 times higher. The high speed of SiC switches also allows for increased efficiencies and reduced passive device requirements for power inverter applications. While lower current (<200A) SiC devices offered by few suppliers have already been introduced for some applications such as on-board vehicle chargers, few devices are fully qualified for automotive applications at these higher current levels of > 200 Amps and > 800 Volts.

This topic seeks to address this device area and rating barrier by demonstrating the successful production of > 200A, > 800V rated SiC devices that are designed for automotive qualification, and suitable for use in electric drive vehicle traction motor inverters. Specifically, devices produced should show automotive application readiness through passing full or partial qualification specifications or standards at high device production yields. Device production quantities are not expected to be sufficient to pass full qualification for Phase 1 projects. Where possible, applicants should show a relationship to, and demonstrate an understanding of, automotive application requirements and environments. Examples include surface and/or substrate treatments and processing, and compatibility with existing power module packaging and processing. Proposals should also

describe the cost of manufacturing SiC switches compared to competing Si switches, including details such as costs and availability of commercial SiC substrates, epi-layers, and additional equipment needed.

These costs should be linked to a commercially viable business model for large scale manufacturing that could be executed in Phase II and should approach price parity with Si switches on a cost per ampere basis.

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

c. Fuel Efficiency Improvement Technologies for Conventional Stoichiometric Gasoline Direct Injection Multi-Cylinder Internal Combustion Engine

Exhaust after-treatment systems have been extensively used and are effective in reducing engine out exhaust emissions from automobile engines. The intent of this subtopic is to pursue the development of technologies that can improve the fuel economy of vehicles with modern Gasoline Direct Injection (GDI) engine powertrains while meeting regulated exhaust emissions requirements with modern 3-way catalytic converters under stoichiometric conditions.

For Phase I, applications must propose the development and demonstration of a functioning prototype by modifying a mass-produced, commercially available, GDI multicylinder automotive reciprocating engine, retrofitted with the subject technology. Reporting must include fuel consumption test results over representative operating points of the engine map with the prototype technology installed compared with test results over the same operating points of the unmodified engine. All fuel consumption testing must be conducted according to automotive industry norms. Only statistically valid fuel economy improvements (95% confidence level) will be considered for Phase II funding consideration.

Phase II work will focus on improving the effectiveness or durability of technologies successfully demonstrated in Phase I.

For this subtopic, novel ignitions systems by themselves will not be considered. Novel ignition systems may be considered as part of an improved technology package if they are necessary to employ other parts of the technology package.

Questions - contact Leo Breton, leo.breton@ee.doe.gov

d. Wide-Range High-Boost Turbocharging System

Turbocharging is recognized as one of the best options for improving fuel economy with engine downsizing. While this strategy has already demonstrated a degree of success, downsizing and fuel economy gains are currently limited by the ability of low-cost turbocharging systems to provide high boost pressures over a wide range of engine speeds.

A turbocharging system is needed that provides high boost pressure from a single turbocharger over an engine speed range of approximately 1000 rpm to 5000 rpm.

Applications are sought to develop and test an advanced low-complexity turbocharging systems that provides high boost pressure at all engine speeds and that has minimal turbo lag. The boosting system should support a maximum engine brake mean effective pressure of at least 25 bar as well as have high efficiency in order to maximize vehicle fuel economy. The turbocharging system should be compatible with current technology as well as emerging technology for engines, such as Miller Cycle engines variable valve timing systems, variable compression ratio engines, etc. Because of the ongoing emphasis on downsizing, these engines are expected to have high mechanical compression ratios, which should be considered.

Low cost solutions are needed to support sales volumes of these highly boosted engines on a large enough scale to have a measurable impact on reducing national fuel consumption. Technologies that will not be considered under this subtopic include electrically, hydraulically or mechanically driven boost devises and the use of multiple turbochargers.

Questions - contact Roland Gravel, Roland.Gravel@ee.doe.gov

e. TECHNOLOGY TRANSFER OPPORTUNITY: Catalyst for Reducing Nitrogen Oxides in Emissions

Nitrogen Oxides (NOx) emissions are well-known contributors to smog, acid rain, and global warming; yet they are among the most difficult pollutants to eliminate from diesel exhaust. Many of the current technologies that reduce NOx cause increases in undesirable particulate emissions. Scientists at Argonne National Laboratory have developed a patented catalyst that can reliably and economically eliminate more than 90 percent of the nitrogen oxide (NOx) emissions from diesel-fueled engines. This technology is currently available for licensing.

Argonne researchers developed the Diesel DeNOx catalyst to help diesel truck manufacturers eliminate NOx emissions, without an increase in particulate emissions. The hydrocarbon based DeNOx catalyst technology utilizes a ceramic material wash-coated with the catalyst consisting of zeolite ZSM-5 exchanged with Cu and including from 5 to 10 percent Ce2O3 as both a stabilizer and a catalyst promoter. It also uses diesel fuel as the required reductant. The catalyst is applied as a coating to a monolithic ceramic brick that is installed in a vehicle's exhaust system. The new technology helps reduce NOx emissions by up to 95 percent. The catalyst (Cu-ZSM-5 coated with nanophase cerium oxide) is active for the conversion of NOx to N2 and can utilize diesel fuel as the reductant. This catalyst overcomes the primary problems that previously plagued these types of catalyst (low water stability and low activity at exhaust temperatures) and has demonstrated longevities of nearly 0.5 million miles of on-road service.

The catalyst can be easily retrofitted on existing diesel engine vehicles. There is a potentially large pool of customers for this technology, given the 11 million diesel engines currently on the road. It is also being tested for stationary source applications such as remote power supplies (gensets) and coal-fired power plants.

Argonne National Laboratory Information:
Licensing Information: Argonne National Laboratory Information Contact: Terry Maynard (tmaynard@anl.gov; 630-252-9771)
License type: Non-exclusive
Patent Status: U.S. Patent 7,220,692 Issued May 22, 2007 USPTO Link: http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=7,220,692.PN.&OS=PN/7,220,692&RS=PN/7,220,692

Questions - contact Ken Howden, Ken.Howden@ee.doe.gov

15. WIND

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Office of Energy Efficiency and Renewable Energy's Wind Energy Technologies Office (www.eere.energy.gov/wind/), seeks applications for innovations that significantly reduce the cost of energy from U.S. wind power resources for land-based, offshore and distributed wind turbines. Today, wind energy provides nearly 5% of the nation's total electricity generation. Between 2003 and the end of 2015, over 75,000 wind turbines, totaling 934 megawatts (MW) in cumulative capacity, were deployed in distributed applications across all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. Additionally, 74 gigawatts (GW) of utility-scale wind turbines are installed across 39 states. With wind power generation exceeding 12% in 11 of those states, wind is a demonstrated clean, affordable electricity resource for the nation. Research and industry experience indicate that wind can be deployed at higher levels while maintaining grid reliability, through analysis of scenarios of wind power supplying 10% of national end-use electricity demand by 2020, 20% by 2030, and 35% by 2050.

Grant applications are sought in the following subtopic:

a. Enabling Wind Power Nationwide

The Wind Energy Technologies Office is seeking proposals for technology innovations with the potential to enable wind power to generate electricity offshore and in all 50 states cost competitively with other sources of generation.

This is an open call and areas of interest include, but are not limited to, the following:

- Lower cost monopole tower and foundation designs for small wind (100kW or less) applications. Current tower and foundation designs can account for up to 50% of installed costs. [1,2]
- Advanced, innovative manufacturing technologies capable of increasing production volumes and reducing costs of wind turbine components for small wind [1,2]
- Advanced manufacturing technologies and processes to facilitate assembly-line production methodologies of offshore foundations for fixed bottom or floating applications [3,5]
- Mooring systems for floating wind turbines in deep waters (over 1000m depth) [3,5]
- Technologies that overcome transportation constraints for towers taller than 140m [4]
- Technologies that overcome transportation constraints for rotor blades longer than 65m [4]
- Technology solutions to mitigate wildlife impacts for land-based and/or offshore wind plants [4,5,6,8]
- Addressing the high investment and processing costs to recycle wind turbine blades, for the existing fleet and/or new blade materials that can facilitate recycling in the next generation of blades [7]
- Innovative materials research/applications, including additive manufacturing, recycling, and low cost carbon fiber that lower cost and increase reliability.

All applications must:

- Propose a tightly structured program which includes technical milestones that demonstrate clear progress, are aggressive but achievable, and are quantitative;
- Include projections for price and/or performance improvements that are tied to a baseline (i.e. Vision or Roadmap targets and/or state of the art products or practices);
- Explicitly and thoroughly differentiate the proposed innovation with respect to existing commercially available products or solutions;
- Include a preliminary cost analysis;
- Justify all performance claims with theoretical predictions and/or relevant experimental data

Questions - contact Michael Derby, michael.derby@ee.doe.gov

REFERENCES:

1. Distributed Wind Energy Association (DWEA), 2015, DWEA Distributed Wind Vision – 2015-2030 Strategies to Reach 30 GW of "Behind-the-Meter" Wind Generation by 2030, p. 26. (http://distributedwind.org/wp-content/uploads/2012/08/DWEA-Distributed-Wind-Vision.pdf)

2. Jenkins, J., Rhoads-Weaver, H., et al., 2013, SMART Wind Roadmap: A Consensus-Based, Shared-Vision Sustainable Manufacturing, Advanced Research & Technology Action Plan for Distributed Wind, Distributed Wind Energy Association, Durango, Colorado, p. 110. (http://distributedwind.org/wp-content/uploads/2016/05/SMART-Wind-Roadmap.pdf)

3. U.S. Department of Energy, 2015, Wind Vision: A New Era for Wind Power in the United States, p. 350. doi:10.2172/1220428 (http://energy.gov/sites/prod/files/2015/03/f20/wv_full_report.pdf)

4. U.S. Department of Energy, 2015, Enabling Wind Power Nationwide, p. 56. doi:10.2172/1220457 (http://energy.gov/sites/prod/files/2015/05/f22/Enabling-Wind-Power-Nationwide_18MAY2015_FINAL.pdf)

5. U.S. Department of Energy, U.S. Department of Interior, 2016, National Offshore Wind Strategy: Facilitating the Development of the Offshore Wind Industry in the United States, p. 84. (http://energy.gov/sites/prod/files/2016/09/f33/National-Offshore-Wind-Strategy-report-09082016.pdf)

6. Schwartz, S.S., 2015, Proceedings of the Wind Wildlife Research Meeting X, Broomfield, CO December 2-5, 2014, National Wind Coordinating Collaborative, American Wind Wildlife Institute, Washington, DC, p. 137. (https://www.nationalwind.org/wp-content/uploads/2014/04/AWWI-NWCC-WWRM-X_Proceedings_Final.pdf)

7. Larsen, H.H., & Sønderberg Petersen, L., 2014, DTU International Energy Report 2014: Wind Energy — Drivers and Barriers for Higher Shares of Wind in the Global Power Generation Mix, Technical University of Denmark, p. 91-97. (http://orbit.dtu.dk/files/102457047/DTU_INTL_ENERGY_REP_2014_WIND.pdf)

8. Sinclair, K., & DeGeorge, E., 2016, Wind Energy Industry Eagle Detection and Deterrents: Research Gaps and Solutions Workshop Summary Report, U.S. Department of Energy, National Renewable Energy Laboratory (NREL). doi:10.2172/1248080 (http://www.nrel.gov/docs/fy16osti/65735.pdf)

16. WATER

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Office of Energy Efficiency and Renewable Energy's Water Power Technologies Office (http://energy.gov/eere/water/water-power-program) researches, tests, evaluates, and develops innovative technologies capable of generating renewable, environmentally responsible, and cost-effective energy from water resources. This includes hydropower, as well as marine and hydrokinetic energy (MHK) technologies, which capture energy from MHK resources (waves as well as riverine, tidal, and ocean currents). The rapid development and deployment of renewable energy systems are vital to reduce industrial and electricity-related greenhouse gas emissions and mitigate climate change.

Grant applications are sought in the following subtopic:

a. Marine and Hydrokinetic Systems for Producing Non-Electric Products

Marine and hydrokinetic (MHK) technologies are a new addition to renewable energy technologies. The nature of MHK technologies also makes them suitable for producing high-value non-electric products, such as alternative fuels [1] (e.g. hydrogen, ammonia) and desalinated water [2]. Furthermore, many non-electric products can easily be transported to regions where needed. Thus, MHK technologies that produce non-electric products have the potential to unlock the vast MHK resources [3] that are stranded in regions of limited transmission infrastructure and electric load.

This subtopic solicits innovative ideas for research and development of MHK systems that produce non-electric products. Applications should propose a structured research project that develops a detailed system design and an economic analysis that demonstrates the commercial potential of the system and its products. Applications must propose a work scope that contains the following activities and progress that must be tracked through measureable milestone.

- Development of a detailed system design, along with a description of the system, how it works, its components, the non-electric product produced, and relevant performance predictions. Drawings, schematics, and simulation results should be provided, as appropriate.
- Development of an economic analysis demonstrating the potential of the system and a projection of the future market opportunities. Relevant details that should be reported include: system cost, system performance metrics (i.e. the cost of the alternate product), and quantification of the amount and value of the non-electric product (e.g. hydrogen, freshwater, etc.) the system produces.
- Identification of the target MHK resource for this system (e.g. wave energy, tidal energy, river current energy, ocean current energy)
- Description of system modularity and scalability
- Evaluation of the environmental acceptability of this system
- Plan for fabricating, testing, and demonstrating a device prototype in subsequent phases, if awarded.

Questions - contact Rajesh Dham, rajesh.dham@ee.doe.gov

REFERENCES:

1. Jensen, S.H., Larsen, P.H., and Mogensen, M., 2007, Hydrogen and Synthetic Fuel Production from Renewable Energy Sources, International Journal of Hydrogen Energy, Volume 32, Issue 15, p. 3253-3257 (https://www.researchgate.net/publication/245147411_Hydrogen_and_synthetic_fuel_production_from_renewable_energy_sources)

2. Kalogirou, S.A., Seawater Desalination Using Renewable Energy Sources, Progress in Energy and Combustion Science, Volume 31, Issue 3, 2005, p. 242-281. (http://www.sciencedirect.com/science/article/pii/S0360128505000146)

3. U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, Marine and Hydrokinetic Resource Assessment and Characterization. (http://energy.gov/eere/water/marine-and-hydrokinetic-resource-assessment-and-characterization)

PROGRAM OFFICE OVERVIEW – OFFICE OF FOSSIL ENERGY

The U.S. Department of Energy's Office of Fossil Energy (FE) plays a key role in helping the United States meet its continually growing need for secure, reasonably priced and environmentally sound fossil energy supplies. FE's primary mission is to ensure the nation can continue to rely on traditional resources for clean, secure and affordable energy while enhancing environmental protection.

Fossil fuels are projected to remain the mainstay of energy consumption (currently 80% of U.S. energy consumption) well into the next century. Consequently, the availability of these fuels, and their ability to provide clean, affordable energy, is essential for global prosperity and security. As the nation strives to reduce its reliance on imported energy sources, FE supports R&D to help ensure that new technologies and methodologies will be in place to promote the efficient and environmentally sound use of America's abundant fossil fuels. To this end, FE is concentrating its 2017 Phase I SBIR-STTR effort on two areas that significantly support and enable development of several fossil energy technologies: Sensors & Controls and Advanced Manufacturing.

For additional information regarding the Office of Fossil Energy priorities, visit http://www.energy.gov/fe/about-us

17. SENSORS AND CONTROLS FOR FOSSIL ENERGY APPLICATIONS

Maximum Phase I Award Amount: $225,000	**Maximum Phase II Award Amount:** $1,500,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The aim of the sensors and controls research area is to make available new classes of sensors and measurement tools that manage complexity, permit low cost, perform robust monitoring, and enable real-time optimization of fully integrated, highly efficient power generation and other fossil fuels-based systems. Research includes sensors capable of monitoring key parameters (temperature, pressure, and gas compositions) while operating in harsh environments; analytical sensors capable of on-line, real-time evaluation and measurement; diagnostics tools for the oil and gas industry; and field detection sensors for rare earth elements processing equipment. Controls development centers around self-organizing information networks and distributed intelligence for process control and decision making.

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

Grant applications are sought in the following subtopics:

a. Novel Concepts for Blockchain-Based Energy Systems

DOE is currently investigating novel approaches to leverage and explore blockchain technology, initially developed within the financial sector, for the realization of robust fossil energy-based systems. In recent years, the financial world has ushered in a new wave of digital currencies including Bitcoin, which is one of the most popular [Nakamoto, 2008; Andreessen, 2014; Chuen, 2015]. Blockchain, which is the underlying infrastructure that allows Bitcoin transactions/payments to be executed, relies on an open ledger to establish trust via consensus from observers within the network [Tapscott, 2016; Lacey, 2016]. A potential example of blockchain implementation for energy systems would be envisioning nodes within sensor networks as 'observers' and the relevant 'transactions' as command signals to actuators. Implementation of a blockchain-based open ledger of all actuation commands ever made by a hardware component may then make it possible to detect and mitigate false command signals (i.e. from hackers) and other cybersecurity threats for the achievement of a robust, reliable system.

Proposals are sought to develop novel concepts for energy systems that rely on blockchain technology to assure robust systems that are less susceptible to cyber-attack. Direct use of real-time measurement data from sensor networks and/or "smart" components that feature embedded instrumentation or other enabling technologies that support the industrial "Internet of Things (IoT)" is strongly encouraged. Project objectives will include software development, preliminary testing to establish proof of concept, and an approach for full integration of the blockchain-based software with system hardware at lab-scale and/or pilot scale.

Questions - contact Sydni Credle at sydni.credle@netl.doe.gov

b. Advanced Hydraulic Fracture Diagnostics

This topic invites proposals for research that is focused on developing novel technologies for more accurately characterizing the orientation and dimensions of hydraulic fractures, in support of analyses to reduce the environmental risks and increase the efficiency of fracturing in unconventional oil and natural gas wells. Understanding the extent to which fractures may intersect with pathways to shallower water supplies is an important aspect of unconventional oil and gas resource development risk mitigation.

The current categories of diagnostic tools (Cipolla and Wright, 2000) include a variety of methods for near-wellbore fracture diagnostics (e.g., production and temperature logs, tracers, borehole imaging) as well as a variety of far-field techniques (e.g., microseismic fracture mapping), but none of these succeed in consistently providing a fully detailed and accurate description of the character of created fractures.

DOE has several projects currently underway that seek to expand the tools available for fracture diagnostics. These include a combination of highly sensitive borehole sensors coupled with proppant-sized acoustic emitters that can signal from within a created

fracture, electromagnetic logging tools that can image the dimensions of a fracture filled with conductive proppant, enhanced logging methods and permanent downhole seismic sensors (Paulsson, 2016; Sharma, 2016).

DOE is interested in building upon its existing research portfolio by developing new ways to reduce the cost and/or enhance the accuracy of existing or under-development technologies and methods for hydraulic fracture diagnostics, or by researching entirely new solutions.

Specific concepts could include:

- Near-wellbore fracture diagnostic methods
- Far-field fracture diagnostic methods

Questions - contact William Fincham at william.fincham@netl.doe.gov

c. System Identification for Highly Coupled Energy Systems

Energy systems with highly coupled physical processes require empirically-based control algorithms that reflect the true operating profile (beyond physics-based model prediction which can be limited for 'unobservable' states) of hardware and components. System identification, which denotes the process by which the operating envelope for a given energy system is identified and characterized for the purpose of control, is an important predictive step in system design and operation (Harun et. al, 2015; Pezzini, et. al., 2015). DOE has ongoing cyber-physical systems research to evaluate critical system identification characterization at pilot scale using step changes with first order plus delay time (FOPDT) and pseudo random binary sequencing (PRBS) for hybrid solid oxide fuel cell and gas turbine (SOFC-GT) applications (Zaccaria, et. al., 2016; Zhou, et. al., 2015). However, other system identification methods such as least squares, state space, non-linear, and closed-loop exist in literature (Ljung, 1999; Holcomb et. al., 2014; Chen, et. al., 2016).

The development and validation of novel methods to perform system identification for fossil energy-based systems (such as steam-/gas-based power cycles, cogeneration or combined heat and power systems, reciprocating engines, etc.) are sought through this SBIR topic. Applicants will leverage an existing sub-pilot or pilot-scale system as a testbed to deploy newly-developed toolsets for system identification.

Proposals should include a full description of the target energy system and a summary of current challenges/limitations for control due to high-level coupling of physical processes. Project objectives will include development of system identification methodology, completion of system identification on the fossil energy-based system of choice, and initial scoping via experiments to validate that models properly emulate system behavior. Benefits of implementing new system identification methodology on system hardware should be presented using quantifiable data results. Versatility of the newly-developed scheme to other energy system applications should also be investigated.

Questions - contact Otis Mills at otis.mills@netl.doe.gov

d. Rare Earth Elements Field and Process Separation Equipment

Proposals are being sought for research that is focused on the development of rare earth element (REE) sensors for application in the field and/or in-process REE separation equipment that are capable of detecting REE elemental concentrations and phase compositions in coal and coal by-products ranging from ppb/ppm to >10wt% in solid and aqueous materials.

Equipment specifications include: (1) portability; (2) wireless, on-line, high speed (1-2 minutes per material being sampled/characterized), real time measurements; (3) high precision, accuracy, and duplicability of generated data (comparable to data generated via ICP-MS); (4) data storage, processing (manipulation) and user friendly presentation capabilities; and (5) internal standards for calibration, assuring quality control (QC).

As a new and developing technology:

- Equipment may combine multiple sensing capabilities as those developed for XRF (x-ray fluorescence), gamma-ray spectrometry, and the like [1-3].
- Equipment shall be capable of detecting and characterizing the concentrations of additional major through minor elements as defined by the operator, e.g., aluminum (Al), phosphorous (P), silicon (Si), calcium (Ca), titanium (Ti), vanadium (V), thorium (Th), arsenic (As), and scandium (Sc).
- Equipment shall have capabilities to assist in the identification and separation of REE-containing fine particles in coal preparation plants.

Specific concepts could include:

- field instrumentation – solid and aqueous materials
- process separation monitoring equipment – solid and aqueous materials

Questions - contact Jessica Mullen at jessica.mullen@netl.doe.gov

e. Other (Sensors and Controls)

In addition to the specific subtopics listed, FE invites grant applications in other areas that fall within the scope of topic descriptions provided above.

Questions - contact Maria Reidpath at maria.reidpath@netl.doe.gov

REFERENCES: Subtopic a:

1. Nakamoto, Satoshi. "Bitcoin: A peer-to-peer electronic cash system." (2008).

2. Andreessen, Marc. “Why Bitcoin Matters.” New York Times, Dealbook (2014).

3. Chuen, David Lee Kuo, ed. Handbook of Digital Currency: Bitcoin, Innovation, Financial Instruments, and Big Data, Academic Press, 2015.

4. Tapscott, Don, and Alex Tapscott. Blockchain Revolution: How the Technology behind Bitcoin is Changing Money, Business, and the World. Penguin, 2016.

5. Lacey, Stephen. 2016. "The Energy Blockchain: How Bitcoin Could be a Catalyst for the Distributed Grid." http://www.greentechmedia.com/articles/read/the-energy-blockchain-could-bitcoin-be-a-catalyst-for-the-distributed-grid (last accessed October 4, 2016).

REFERENCES: Subtopic b:

1. Cipolla, C.L. and Wright, C.A. 2000, "State-of-the-Art in Hydraulic Fracture Diagnostics," Presented at the SPE Asia Pacific Oil and Gas Conference and Exhibition, Brisbane, Australia, 16–18 October. SPE-64434-MS. http://dx.doi.org/10.2118/64434-MS

2. Paulsson, B., 2016, "Fiber Optic Seismic Vector Sensor Tracking of Acoustic Micro Emitters to Optimize Unconventional Oil and Gas Development" http://www.netl.doe.gov/File%20Library/Events/2016/fy16%20cs%20rd/Wed/Paulsson-Fluidion.pdf

3. Sharma, M., 2016, "Fracture Diagnostics Using Low Frequency EM Induction and Electrically Conductive Proppant" http://www.netl.doe.gov/File%20Library/Events/2016/fy16%20cs%20rd/Wed/Sharma.pdf

REFERENCES: Subtopic c:

1. Harun, N.F., Tucker, D., and Adams, T. A. II., "Impact of Fuel Composition Transients on SOFC Performance in Gas Turbine Hybrid Systems," Applied Energy, 164:446-461, doi:10.1016/j.apenergy.2015.11.031.

2. Pezzini, P.; Celestin, S.; Tucker, D. "Control Impacts of Cold-Air Bypass on Pressurized Fuel Cell Turbine Hybrids," Journal of Fuel Cell Science and Technology, 12(1):011006 (February 2015); doi: 10.1115/1.4029083.

3. Zhou, N.; Yang, C.; Tucker, D.; Pezzini, P.; Traverso, A., "Transfer Function Development for Control of Fuel Cell Turbine Hybrid Systems," International Journal of Hydrogen Energy, 40:1967-1979 (2015): doi:10.1016/j.ijhydene.2014.11.107.

4. Zaccaria, V., Tucker, D., Traverso, A., "Transfer Function Development for SOFC/GT Hybrid Systems Control using Cold Air Bypass", Applied Energy 165 (2016) 695–706, doi: 10.1016/j.apenergy.2015.12.094.

5. L. Ljung "System Identification, theory for the user," 1999 Prentice Hall PTR;

6. Chad M. Holcomb, Raymond. A. de Callafon, Robert E. Bitmead, "Closed-loop nonlinear system identification applied to gas turbine analytics," Proceedings of ASME Turbo Expo (2014), paper no. GT2014-26059;

7. Jinwei Chen, Huisheng Zhang, Shilie Weng, "Study on nonlinear identification SOFC temperature model based on particle swarm optimization-least squares support vector regression," Proceedings of ASME Turbo Expo (2016), paper no. GT2016-56236;

REFERENCES: Subtopic d:

1. NETL REE EDX portfolio site https://edx.netl.doe.gov/ree/

2. NETL REE website http://www.netl.doe.gov/research/coal/rare-earth-elements

3. NI 43-101 Technical Reports – Example: G.Gagnon, G.Rousseau, Y.Camus, and J.Gagné, SGS Canada Inc., Preliminary Economic Assessment – Ashram Rare Earth Deposit for Commerce Resources Corp., January 7, 2015.

18. ADVANCED MANUFACTURING FOR FOSSIL ENERGY TECHNOLOGIES

Maximum Phase I Award Amount: $225,000	**Maximum Phase II Award Amount:** $1,500,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Advanced manufacturing is emerging as an especially potent driver of future economic growth. Advanced manufacturing can be used to improve existing manufacturing processes and rapidly introduce new prototypes and products. These paradigm-shifting aspects of advanced manufacturing offer the potential to spin off entirely new industries and lead to production methods that are most likely to remain in the United States because they are hard to imitate. Within the Department of Energy, advanced manufacturing may also be defined in terms of improvements in lifecycle energy use. Advanced manufacturing methods and products that lead to reduced energy consumption are a focus. Additive manufacturing methods are also a focus for advanced materials because they show promise in enabling the manufacturing of parts from, for example, nickel super-alloys and advanced stainless steels, which are typically difficult to weld or machine and are also quite expensive.

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

a. Additive Manufacturing of Extreme Environment Materials for Large Parts

DOE is currently exploring a suite of transformational technologies for fossil energy-based power production, including (but not limited to) supercritical CO_2 (sCO_2) cycles, chemical looping combustion (CLC), direct power extraction (DPE), and pressurized combustion. Development of extreme environment materials (EEM) and related advanced manufacturing processes for system components that are able to withstand the typically harsh environments observed for these FE components while also achieving sought-after

performance is critical. Additive manufacturing (AM) is of great interest for the production of fossil energy-based system components due to its ability to allow flexibility of design, production of complex parts, and lower cost due to reduced materials requirement, decreased lead times, etc. (Frazier, 2014). However, the ability of AM to produce dimensionally large parts from EEM is lacking (ORNL, 2016) and more R&D is needed to realize the full potential of AM as a viable alternative to traditional manufacturing processes (i.e. investment casting, hot isostatic pressing, etc.) (Mercelis, 2006; Gu, 2012; Gong, 2012; Williams, 2016).

Proposals are sought to explore scale-up of additive manufacturing (AM) processes for extreme environment materials (EEM) such as nickel-based superalloys, ceramics, and refractory alloys. Target application would be any fossil energy-relevant system component with a major axis of greater than 4 feet.

Applicants must specify the fossil energy component of interest, relevant specification for material performance (microstructure, mechanical properties, etc.), proposed additive manufacturing approach, and summary of critical fabrication issues including relevant mitigation techniques. Manufacturing process modeling for microstructural design and performance prediction of AM-fabricated parts is encouraged. Project objectives will include material procurement and preliminary experimentation to prove feasibility of the stated manufacturing approach. Methodology for possible full-scale production of target component as well as approach for relevant testing to confirm microstructural and mechanical integrity must also be provided.

Questions - contact Rick Dunst at richard.dunst@netl.doe.gov

b. Additive Manufacturing for a Complete Solid Oxide Fuel Cell (SOFC)

Additive manufacturing (AM) is used to create components in a layering manner to fabricate products with intricate shapes. AM has been identified as a potentially attractive option for the manufacture of high temperature performance components used in SOFC technology. AM manufacturing techniques will address the need for components processing that not only maintains structural integrity but also offers the ability to perform multiple functions as well. AM also enables the design and synthesis of materials whose microstructure and properties allow for the construction of such components.

Grant applications are sought for research and development that uses AM techniques to fabricate a complete SOFC cell (electrolyte, anode and cathode) such that each component has functionality and characteristics with potential to exceed the performance requirements of current state of the art SOFC components. Applicants must present a clear plan that outlines how entire SOFC cell architectures would be fabricated and implemented, and discuss performance attributes. A complete description of the manufacturing process required to achieve the proposed architectures should be provided to facilitate analysis of potential cost issues and implementation complexity. Applications that focus on individual

cell components will be considered non-responsive. Applications that focus on fuel cell technology other than SOFC will also be considered non-responsive.

Questions - contact Rin Burke at patcharin.burke@netl.doe.gov

c. Other (Advanced Manufacturing)

In addition to the specific subtopics listed, FE invites grant applications in other areas that fall within the scope of topic descriptions provided above.

Questions - contact Maria Reidpath at maria.reidpath@netl.doe.gov

REFERENCES: Subtopic a:

1. Frazier, W.E., 2014, Metal Additive Manufacturing: A Review, Journal of Materials and Engineering and Performance, Volume 23, Issue 6, p. 1917-1928. (http://link.springer.com/article/10.1007/s11665-014-0958-z)

2. Babu, S., Love, L.J., Peter, W., and Dehoff, R., 2016, Report on Additive Manufacturing for Large Scale Metals Workshop, Oak Ridge National Laboratory (ORNL), Knoxville TN, p. 37. (http://info.ornl.gov/sites/publications/files/Pub62831.pdf)

3. Mercelis, P., and Kruth, J.P., 2006, Residual Stresses in Selective Laser Sintering and Selective Laser Melting, Rapid Prototyping Journal, Volume 12, Issue 5, p. 254-265. (http://www.emeraldinsight.com/doi/abs/10.1108/13552540610707013)

4. Gu, D. D., et al., 2012, Laser Additive Manufacturing of Metallic Components: Materials, Processes and Mechanisms, International Materials Reviews, Volume 57, Issue 3, p. 133-164. (http://www.tandfonline.com/doi/abs/10.1179/1743280411Y.0000000014)

5. Gong, X., Anderson, T., and Chou, K., 2012, Review on Powder-Based Electron Beam Additive Manufacturing Technology, ASME/ISCIE 2012 International Symposium on Flexible Automation, American Society of Mechanical Engineers, p. 507-515. (http://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=1719821)

6. Williams, S.W., et al, 2016, Wire + Arc Additive Manufacturing, Materials Science & Engineering, Volume 32, Issue 7, p. 641-647. (http://www.tandfonline.com/doi/abs/10.1179/1743284715Y.0000000073)

REFERENCES: Subtopic b:

1. Khatri-Chhetri, P., Datar, A., and Cormier, D., 2012, Novel SOFC Processing Techniques Employing Printed Materials, Advances in Materials Science for Environmental and Energy Technologies: Ceramic Transactions, Volume 236, p. 129-139. (http://onlinelibrary.wiley.com/doi/10.1002/9781118511435.ch14/summary)

2. Geisendorfer, N., Jakus, A.E., et al., 2016, Symposium EE7: Mechanics of Energy Storage and Conversion-Batteries; Thermoelectrics and Fuel Cells. (https://mrsspring.zerista.com/poster/member/57110)

3. Kulkarni, N.P., Tandra, G., et al.,2009, Fuel Cell Development Using Additive Manufacturing Technologies – A Review, Department of Mechanical and Areospace Engineering, Missouri University of Science and Technology, Rolla, MO, p. 18. (http://sffsymposium.engr.utexas.edu/Manuscripts/2009/2009-59-Kulkarni.pdf)

4. U.S Department of Energy, NETL, Solid Oxide Fuel Cells. (http://www.netl.doe.gov/research/coal/energy-systems/fuel-cells)

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 the nation 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 Fusion Energy Sciences (FES) mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished through the study of plasma, the fourth state of matter, and how it interacts with its surroundings principles. FES has four strategic goals:

- Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source;
- Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment;
- Pursue scientific opportunities and grand challenges in high energy density plasma science to better understand our universe, and to enhance national security and economic competitiveness, and;
- Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic competiveness and to create opportunities for a broader range of science-based applications.

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 build and operate the next major step in the fusion energy sciences research program, a facility called “ITER”. The purpose of ITER is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes. Experimental operations are expected to demonstrate production of at least 10 times the power used to heat the fusion fuel and to provide a platform to validate proposed commercial-grade technologies needed for power production. ITER will achieve First Plasma in approximately 10 years and will go to full power Deuterium-Tritium operations in approximately 20 years.

The following topics are restricted to advanced technologies and materials for fusion energy systems, fusion science, and technology relevant to magnetically confined plasmas, high energy density plasmas and inertial fusion energy, and low-temperature plasmas, as described below.

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

19. ADVANCED TECHNOLOGIES AND MATERIALS FOR FUSION ENERGY SYSTEMS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

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 (FES) can be found at the FES Website, http://www.science.energy.gov/fes.

Grant applications are sought in the following subtopics:

a. Plasma Facing Components

The plasma facing components (PFCs) in energy producing fusion devices will experience unprecedentedly high heat, particle, and neutron fluxes, leading to large perturbations and reconstitution of the base material over the lifetime of the PFC. The goal of this program is to establish the feasibility of PFCs that meet demanding requirements for performance, core compatibility, and safety.

Grant applications are sought for:

Development of solid PFCs. These PFCs are typically envisioned as specialized plasma facing materials (typically tungsten or tungsten alloy) joined to either a water-cooled, copper-alloy heat sink or advanced, helium-cooled, refractory heat sink. Research is sought to explore: (1) innovative tungsten alloys having good thermal conductivity, resistance to recrystallization and grain growth, improved mechanical properties (e.g., strength and ductility), and resistance to thermal fatigue; (2) novel coatings or bulk specialized low-Z materials for improved plasma performance; (3) innovative heat sink and component designs for enhanced cooling; and (4) innovative joining and fabrication methods for PFC manufacturing.

Development of liquid metal PFCs. Materials of interest included liquid lithium, gallium, tin, or mixture thereof. Concepts of interest include thin film systems (up to cm scale) with flow speeds ranging from stagnant to fast flow. Research is sought to explore: (1) techniques for the replenishment and control of stagnant liquid metal surfaces; (2) techniques for the production, control, and removal of flowing liquid metal thin films (velocity 0.01 to 10 m/s); (3) advances in materials and interfaces that allow for the production and control of uniform, well-adhered films; and (4) techniques for active control of liquid metal surface and flow stabilization in the presence of plasma instabilities (time and space varying magnetic field).

Questions - contact Daniel Clark, daniel.clark@science.doe.gov

b. Blanket and Safety Technologies

The breeder blanket is a complex, multi-function, multi-material engineered system that is designed to efficiently convert fusion power into electricity and breed tritium fuel by capturing fusion neutrons in lithium. In addition to the blanket, various other systems requirements include heat transport loops and exchangers, tritium processors, nuclear shielding, and sensor arrays. The goal of this program is to address the challenges in harnessing fusion power through developing a safe and efficient fuel and heat extraction system required for a self-sufficient, electricity-generating fusion reactor.

Grant applications are sought for:

Development of solid breeder blanket materials, concepts, and technologies. Research is sought to explore: (1) high density (up to~80%) and/or high breeding ratio materials; (2) materials with increased structural integrity, thermo-mechanical properties, and absence of major geometry changes (such as sintering in pebble beds) in intense radiation environment; (3) concepts with increased thermal conductivities and contact (as opposed to point contacts between pebbles and walls); and (4) tools for simulation and analysis of materials and systems for solid breeders that leverage advanced computational techniques.

Development of liquid breeder materials, concepts, and technologies. Research is sought to explore: (1) high breeding capacity materials and designs; (2) innovative breeder materials that are not influenced by the magnetohydrodynamic (MHD) effect, can operate at high temperatures (400-700 ˚C), have increased chemical compatibility with current generation reduced activation materials (RAFM steels, ODS steels, SiC, W), and are conducive to tritium extraction; and (3) tools for simulation and analysis of materials and systems for liquid breeders that leverage advanced computational techniques.

Development of tritium fuel cycle management and processing techniques. Research is sought to explore: (1) tritium extraction and purification technologies for proposed breeder, coolant, and liquid PFC working fluids (Li-Pb, He gas, Li, Sn, Ga); (2) simulation tool to predict and model tritium production, transport, and retention within coolant/breeder loops; and (3) plant level tritium management, containment, and safety tools and systems development.

Development of requisite breeder blanket diagnostics such as liquid metal flow sensors, tritium concentration sensors, etc.

Development of neutronics simulation tools for systems level analysis. Tools are sought to explore: (1) prediction of the fusion Tritium Breeding Ratio (TBR) in breeder blankets; (2) material irradiation damage calculations, including both displacement and transmutation

effects as a function of position and fluence; and (3) prediction of residual radioactivity for safety and remote handling considerations. Ideally these tools are plug-ins or compatible modules within existing commercial design software codes to enhance the integration, validation, and adoption of the tools.

Questions - contact Albert Opdenaker, albert.opdenaker@science.doe.gov

c. Superconducting Magnets and Materials

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

Grant applications are sought for:

Innovative and advanced superconducting materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs. Of specific interest are materials such as YBCO conductors that are easily adaptable to bundling into high current cables carrying 30-60 kA. Desirable characteristics include high critical currents at temperatures from 4.5 K to 50 K, magnetic fields in the range 5 T to 20 T, higher copper fractions, low transient losses, low sensitivity to strain degradation effects, high radiation resistance, and improved methods for cabling tape conductors taking into account twisting and other methods of transposition to ensure uniform current distribution.

Novel methods for joining coil sections for manufacture of demountable magnets that allow for highly reliable, re-makeable joints that exhibit excellent structural integrity, low electrical resistance, low ac losses, and high stability in high magnetic field and in pulsed applications. These include conventional lap and butt joints, as well as very high current plate-to-plate joints. Reliable sliding joints can be considered.

Innovative structural support methods and materials, and magnet cooling and quench protection methods suitable for operation in a fusion radiation environment that results in high overall current density magnets.

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

measurement of distributed and local temperature or strain for diagnostic and scientific studies of conductor behavior and code calibration.

Radiation-resistant electrical insulators, e.g., wrap able inorganic insulators and low viscosity organic insulators that exhibit low gas generation under irradiation, less expensive resins and higher pot life; and insulation systems with high bond and higher strength and flexibility in shear.

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

d. Structural Materials and Coatings

Fusion materials and structures must function for a long time in a uniquely hostile environment that includes combinations of high temperatures, high stresses, reactive chemicals, and intensely damaging radiation. The goal of this program is to establish the feasibility of designing, constructing and operating a fusion power plant with materials and components that meet demanding objectives for safety, performance, economics, and environmental impact.

Grant applications are sought for:

Development of current generation reduced activation ferritic martensitic (RAFM) steels technologies, with a focus on joining and fabrication techniques. Such techniques could include but are not limited to appropriate welding, hot-isostatic pressing, hydroforming, and investment casting methods, as well as effective post joining heat treatment techniques and procedures. Appropriate fabrication technologies must produce components within dimensional tolerances, while meeting minimum requirements on mechanical and physical properties.

Development of oxide dispersion strengthened (ODS) ferritic steels and technologies. Approaches of interest include the development of low cost production techniques, improved isotropy of mechanical properties, development of joining and fabrication methods that maintain the properties of the ODS steel, and development of improved ODS steels with increased operating temperatures (up to ~800 ˚C).

Development of functional materials and coatings for use in fusion reactors. System applications of high priority include the Pb-Li breeder blanket concept and liquid metal (lithium, tin, and gallium) PFC concepts. Research is sought to explore: (1) materials compatibility issues; (2) tritium (hydrogen) permeation barriers; and (3) electrical insulation materials (to reduce the pressure drop due to the magneto-hydrodynamic (MHD) effects). Proposals must include considerations towards compatibility with the coated structural alloy and/or working fluid for long-time operation at elevated temperatures (500-700˚C), including cyclic thermal loading, and potential application issues associated with implementation on large-scale system components.

Questions - contact Daniel Clark, daniel.clark@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

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

REFERENCES: Subtopic a:

1. U.S. Department of Energy, Office of Fusion Energy Sciences, 2009, Research Needs for Magnetic Fusion Energy Sciences, Report of the Research Needs Workshop (ReNeW), Bethesda, Maryland. June 8-12, p. 422. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/Res_needs_mag_fusion_report_june_2009.pdf)

2. U.S. Department of Energy, Office of Science, Fusion Energy Sciences Advisory Committee, 2012, Opportunities for Fusion Materials Science and Technology Research Now and During the ITER Era, p. 141, DOE/SC-0149. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/20120309/FESAC-Materials-Science-final-report.pdf)

REFERENCES: Subtopic b:

1. U.S. Department of Energy, Office of Fusion Energy Sciences, 2009, Research Needs for Magnetic Fusion Energy Sciences, Report of the Research Needs Workshop (ReNeW), Bethesda, Maryland. June 8-12, p. 285-292. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/Res_needs_mag_fusion_report_june_2009.pdf)

2. U.S. Department of Energy, Office of Science, Fusion Energy Sciences Advisory Committee, 2012, Opportunities for Fusion Materials Science and Technology Research Now and During the ITER Era, p. 141, DOE/SC-0149. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/20120309/FESAC-Materials-Science-final-report.pdf)

3. Kessel, C. E., et al, 2012, Fusion Nuclear Science Pathways Assessment (FNS-PA), Princeton Plasma Physics Laboratory, p. 290, PPPL-4736. (http://bp.pppl.gov/pub_report/2012/PPPL-4736-abs.html)

REFERENCES: Subtopic c:

1. U.S. Department of Energy, Office of Fusion Energy Sciences, 2009, Research Needs for Magnetic Fusion Energy Sciences, Report of the Research Needs Workshop (ReNeW), Bethesda, Maryland. June 8-12, p. 285-292. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/Res_needs_mag_fusion_report_june_2009.pdf)

2. Minervini, J.V., & Schultz, J.H., 2003, U.S. Fusion Program Requirements for Superconducting Magnet Research, IEEE Transactions on Applied Superconductivity, Volume 13, Issue 2, p. 1524-1529. (http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1211890)

3. Bromberg, L., et al, 2001, Options for the Use of High Temperature Superconductor in Tokamak Fusion Reactor Designs, Fusion Engineering and Design, Volume 54, p. 167-180. (http://www-ferp.ucsd.edu/LIB/REPORT/JOURNAL/FED/01-bromberg.pdf)

4. Ekin, J.W., 2006, Experimental Techniques for Low-Temperature Measurements: Cryostat Design, Material Properties, and Superconductor Critical-Current Testing, Oxford University Press, p.704, ISBN13: 978-0-19-857054-7. (https://global.oup.com/academic/product/experimental-techniques-9780198570547?cc=us&lang=en&)

REFERENCES: Subtopic d:

1. U.S. Department of Energy, Office of Fusion Energy Sciences, 2009, Research Needs for Magnetic Fusion Energy Sciences, Report of the Research Needs Workshop (ReNeW), Bethesda, Maryland. June 8-12, p. 285-292. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/Res_needs_mag_fusion_report_june_2009.pdf)

2. U.S. Department of Energy, Office of Science, Fusion Energy Sciences Advisory Committee, 2012, Opportunities for Fusion Materials Science and Technology Research Now and During the ITER Era, p. 141, DOE/SC-0149. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/20120309/FESAC-Materials-Science-final-report.pdf)

20. FUSION SCIENCE AND TECHNOLOGY

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Fusion Energy Sciences program currently supports several fusion-related 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 (a) measuring magnetized-plasma parameters, (b) for low-temperature and multi-phase plasmas, (c) for magnetized-plasma simulation, control, and data analysis, and (d) for overcoming deleterious plasma effects during discharges. 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 (FES) can be found in the FES website at http://science.energy.gov/fes/.

Grant applications are sought in the following subtopics:

a. Diagnostics

Diagnostics are key to advancing our ability to predict and control the behavior of fusion plasmas. Applications are sought for the development of advanced diagnostic techniques to enable new way of studying plasma behavior, or to measure plasma parameters not previously accessible, or at a level of detail greater than previously possible, or at a

substantially reduced cost or complexity, and for the development needed in applying existing diagnostics to new, relatively unexplored, or unfamiliar plasma regimes or scenarios. Development of diagnostics meeting needs for advancing the science of boundary and pedestal physics, explosive instability (including ELMs and disruptions), and long-pulse magnetized plasmas are particularly welcome. Development leading to dramatic reduction in the cost of particle accelerators (e.g. MEMS-based accelerators) suitable for use as a diagnostic for magnetic fusion experiments are encouraged, as well as new detectors and associated technologies to work with these accelerators as a diagnostic system. Requests seeking funding for the routine application or operation of proven and matured diagnostic techniques at the major fusion facilities will not be considered under this subtopic. Such diagnostic applications are typically funded via separate solicitations as part of experimental facilities, based on their own research program priorities.

Questions - contact Francis Thio, francis.thio@science.doe.gov

b. Components for Heating and Fueling of Fusion Plasmas

Grant applications are sought to develop components related to the generation, transmission, and launching of high power electromagnetic waves in the frequency ranges of Ion Cyclotron Resonance Heating (ICRH, 50 to 300 MHz), Lower Hybrid Heating (LHH, 2 to 10 GHz), and Electron Cyclotron Resonance (or Electron Bernstein Wave) Heating (ECRH / EBW, 28 to 300 GHz). These improved components are sought for the microwave heating systems of the fusion facilities in the United States and facilities under construction including ITER. Components of interest include power supplies, high power microwave sources or generators, fault protection devices, transmission line components, and antenna and launching systems. Specific examples of some of the components that are needed include tuning and matching systems, unidirectional couplers, circulators, mode convertors, windows, output couplers, loads, energy extraction systems from spent electron beams and particle accelerators, and diagnostics to evaluate the performance of these components. Of particular interest are components that can safely handle a range of frequencies and increased power levels.

For the ITER project, the United States will be supplying the transmission lines for both the ECRH (2 MW/line) system, at a frequency of 170 GHz, and for the ICRH system (6 MW/line), operating in the range of 40 – 60 MHz.. For this project, grant applications are needed for advanced components that are capable of improving the efficiency and power handling capability of the transmission lines, in order to reduce losses and protect the system from overheating, arcing, damage or failure during the required long pulse operation (~3000s). Examples of components needed for the ECRH transmission line include high power loads, low loss miter bends, polarizers, power samplers, windows, switches, and dielectric breaks. Examples of components needed for the ICRH transmission line include high power loads, tuning stubs, phase shifters, switches, arc localization methods, and in line dielectric breaks. For the ECRH and ICRH ITER transmission lines, improved techniques are needed for the mass production of components, in order to reduce cost. Lastly,

advanced computer codes are needed to simulate the radiofrequency, microwave, thermal, and mechanical components of the transmission lines.

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

c. Simulation and Data Analysis Tools for Magnetically Confined Plasmas

The predictive simulation of magnetically confined fusion plasmas is important for the design and evaluation of plasma discharge feedback and control systems; the design, operation, and performance assessment of existing and proposed fusion experiments; the planning of experiments on existing devices; and the interpretation of the experimental data obtained from these experiments. Developing a predictive simulation capability for magnetically confined fusion plasmas is very challenging because of the enormous range of overlapping temporal and spatial scales; the multitude of strongly coupled physical processes governing the behavior of these plasmas; and the extreme anisotropies, high dimensionalities, complex geometries, and magnetic topologies characterizing most magnetic confinement configurations.

Although considerable progress has been made in recent years toward the understanding of these processes in isolation, there remains a critical need to integrate them in order to develop an experimentally validated integrated predictive simulation capability for magnetically confined plasmas. In addition, the increase in the fidelity and level of integration of fusion simulations enabled by advances in high performance computing hardware and associated progress in computational algorithms has been accompanied by orders of magnitude increases in the volume of generated data. In parallel, the volume of experimental data is also expected to increase considerably, as U.S. scientists have started collaborations on a new generation of overseas long-pulse superconducting fusion experiments. Accordingly, a critical need exists for developing data analysis tools addressing big data challenges associated with computational and experimental research in fusion energy science.

Grant applications are sought to develop simulation and data analysis tools for magnetic fusion energy science addressing some of the challenges described above. Areas of interest include: (1) verification and validation tools, including efficient methods for facilitating comparison of simulation results with experimental data; (2) methodologies for building highly configurable and modular scientific codes and flexible user-friendly interfaces; (3) tools for creating interfaces to legacy codes; and (4) remote collaboration tools that enhance the ability of geographically distributed groups of scientists to interact and collaborate in real-time.

The simulation and data analysis tools should be developed using modern software techniques, should be capable of exploiting the potential of current and next generation high performance computational systems, and should be based on high fidelity physics models. The applications submitted in response to this call should have a strong potential

for commercialization and should not propose work that is normally funded by program funds. Although applications submitted to this topical area should primarily address the simulation and data analysis needs of magnetic fusion energy science, applications proposing the development of tools and methodologies which have a broader applicability, and hence increased commercialization potential, are encouraged.

Questions - contact John Mandrekas, john.mandrekas@science.doe.gov

d. Components and Modeling Support for Validation Platforms for Fusion Science

Small-scale plasma research experiments in the FES program have the long-term performance measure of demonstrating enhanced fundamental understanding of magnetic confinement and improving the basis for future burning plasma experiments. This can be accomplished through investigations and validations of the linkage between prediction and measurement for scientific leverage in testing the theories and scaling the phenomena that are relevant to future burning plasma systems. This research includes investigations in a variety of concepts such as stellarators, spherical tori, and reversed field pinches. Key program issues include initiation and increase of plasma current; dissipation of plasma exhaust power; symmetric-torus confinement prediction; stability, continuity, and profile control of low-aspect-ratio symmetric tori; quasi-symmetric and three-dimensional shaping benefits to toroidal confinement performance; divertor design for three-dimensional magnetic confinement configurations, and the plasma-materials interface. Grant applications are sought for scientific and engineering developments, including computational modeling, in support of current experiments in these research activities, in particular for the small-scale concept exploration experiments. The proposed work should have a strong potential for commercialization. Overall, support of research that can best help deepen the scientific foundations of understanding and improve the tokamak concept is an important focus area for grant applications.

Questions - contact Sam Barish, sam.barish@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

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

REFERENCES: Subtopic b:

1. Phillips, C.K., and Wilson, J. R., 2011, Radio Frequency Power in Plasmas: Proceedings of the 19th Topical Conference, AIP Conference Proceedings, Volume 1406, p.1-2, Newport, Rhode Island. June 1-3, ISBN: 978-0-7354-0978-1. (http://scitation.aip.org/content/aip/proceeding/aipcp/1406)

2. Henderson, M.A., et al., 2009, A Revised ITER EC System Baseline Design Proposal, Proceedings of the 15th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating, Yosemite National Park, California, March 10-13, World Scientific Publishing Co., ISBN: 978-981-281-463-0. (http://adsabs.harvard.edu/abs/2009ecee.conf..458H)

3. Lohr, J., et al., 2011, The Multiple Gyrotron System on the DIII-D Tokamak. Journal of Infrared, Millimeter and Terahertz Waves, Volume 32, Issue 3, p. 253-273. (http://www.springerlink.com/content/9t6k415838802066/)

4. Omori, T., et al., 2011, Overview of the ITER EC H&CD System and Its Capabilities, Fusion Engineering and Design, Volume 86, Issues 6-8, p. 951-954. (http://infoscience.epfl.ch/record/176865)

5. Shapiro, M.A., et al., 2010, Loss Estimate for ITER ECH Transmission Line Including Multimode Propagation, Fusion Science and Technology, Volume 57, Issue 3. p. 196-207. (http://www.new.ans.org/pubs/journals/fst/a_9467)

REFERENCES: Subtopic c:

1. Terry, P.W., et al., 2008, Validation in Fusion Research: Towards Guidelines and Best Practices, Physics of Plasmas, Volume 15, Issue 062503. (http://plasma.physics.wisc.edu/uploadedfiles/journal/Terry524.pdf)

2. Schissel, P., et al., 2006, Collaborative Technologies for Distributed Science: Fusion Energy and High-energy Physics, Journal of Physics: Conference Series, Volume 46, p. 102-106. (http://iopscience.iop.org/1742-6596/46/1/015)

3. Klasky, S., et al., 2005, Data Management on the Fusion Computational Pipeline, Journal of Physics: Conference Series, Volume 16, p. 510-520. (http://iopscience.iop.org/1742-6596/16/1/070)

4. Cohen, J., & Garland, M., 2009, Solving Computational Problems with GPU Computing, Computing in Science and Engineering, Volume 11, p. 58-63. (http://www.computer.org/csdl/mags/cs/2009/05/mcs2009050058-abs.html)

5. Greenwald, M., et al., 2012, A Metadata Catalog for Organization and Systemization of Fusion Simulation Data, Fusion Engineering and Design, Volume 87, Issue 12, p. 2205-2208. (http://www.sciencedirect.com/science/article/pii/S0920379612002025)

6. U.S. Department of Energy, 2015, Report of the Workshop on Integrated Simulations for Magnetic Fusion Energy Sciences, Rockville, MD, June 2-4. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/2016/ISFusionWorkshopReport_11-12-2015.pdf)

REFERENCES: Subtopic d:

1. 2013, Proceedings from the Workshop on Exploratory Topics in Plasma and Fusion Research (EPR2013), Fort Worth, Texas. February 12-15. (http://www.iccworkshops.org/epr2013/proceedings.php)

2. U.S. Department of Energy, Office of Fusion Energy Sciences, 2009, Research Needs for Magnetic Fusion Energy Sciences, Report of the Research Needs Workshop (ReNeW), Bethesda, Maryland. June 8-12. (http://science.energy.gov/~/media/fes/pdf/workshop-reports/Res_needs_mag_fusion_report_june_2009.pdf)

21. HIGH ENERGY DENSITY PLASMAS AND INERTIAL FUSION ENERGY

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

High-energy-density laboratory plasma (HEDLP) physics is the study of ionized matter at extremely high density and temperature, specifically when matter is heated and compressed to a point that the stored energy in the matter reaches approximately 100 billion Joules per cubic meter (the energy density of a hydrogen molecule). This corresponds to a pressure of approximately 1 million atmospheres or 1 Mbar.

Research in HEDLP forms the scientific foundation for developing scenarios that could facilitate the transition from laboratory inertial confinement fusion (ICF) to inertial fusion energy (IFE).

While substantial scientific and technical progress in inertial confinement fusion has been made during the past decade, many of the technologies required for an integrated inertial fusion energy system are still at an early stage of technological maturity. This relative immaturity ensures that commercially viable IFE remains a long-term (>15 years) objective. Research and development activities are sought which address specific technology needs (specified below), necessary to both assess and advance IFE. Given the long-term prospects for IFE, applications submitted under this topical area must also clearly describe their potential/plans for short-term (2-10 years) commercialization in other commercial industries such as telecommunications, biomedical, etc.

Grant applications are sought in the following subtopics:

a. Driver Technologies

Inertial fusion energy hinges on the ability to compress an ICF target in tens of nanoseconds and repeat this process tens of times per second. Thus, the development of technologies is needed to build a driver (e.g., lasers, heavy-ions, pulsed power) that can meet the IFE requirements for energy on target, efficiency, repetition rate, durability, and cost. Specific areas of interest include but are not limited to: wavelength and beam quality for lasers, brightness for lasers and heavy ions, and pulse shaping and power.

Questions - contact Kramer Akli, Kramer.akli@science.doe.gov

b. Ultrafast Diagnostics

The development of ultrafast diagnostics is needed to assess driver and plasma conditions on sub-picosecond time scales. This technology has the potential to enable the development and deployment of feedback systems capable of ensuring the necessary reliability required for commercially viable IFE.

Specific areas of interest include but are not limited to the generation, detection, and control of nonlinear optical processes in plasmas.

Questions - contact Kramer Akli, Kramer.akli@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Kramer Akli, Kramer.akli@science.doe.gov

REFERENCES:

1. U.S. Department of Energy, 2009, Advancing the Science of High Energy Density Laboratory Plasmas, Report of the High Energy Density Laboratory Plasmas Panel of the Fusion Energy Sciences Advisory Committee, p.184. (http://science.energy.gov/~/media/fes/fesac/pdf/2009/Fesac_hed_lp_report.pdf)

22. LOW TEMPERATURE PLASMAS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Low-temperature plasma science and engineering addresses research and development in partially ionized gases with electron temperatures typically below 10 eV. This is a field that accounts for an enormous range of practical applications, from light sources and lasers to surgery and making computer chips, among many others. The commercial and technical value of low temperature plasma (LTP) is well established where much of this benefit has resulted from empirical development. As the technology becomes more complex and addresses new fields, such as energy and biotechnology, empiricism rapidly becomes inadequate to advance the state of the art. Predictive capability and improved understanding of the plasma state becomes crucial to address many of the intellectually exciting scientific challenges of this field.

Building upon fundamental plasma science, further developments are sought in plasma sources, plasma surface interactions, and plasma control science that can enable new plasma

technologies or marketable product and impact in other areas or disciplines leading to even greater societal benefit. The focus is on utilizing fundamental plasma science knowledge and turning it into new applications.

Use of readily available LTPs involving very little plasma science in a direct application of another field will not be considered. All research proposals must have a strong commercialization potential.

Grant applications are sought in the following subtopics:

a. Low-Temperature Plasma Science and Technology for Biology and Biomedicine

One of the current challenges identified in the areas of biological and medical applications of low-temperature plasmas is improving our current understanding and scientific knowledge in the area of plasma-biomatter interactions. Specific examples include but are not limited to: plasma-based bacterial inactivation, cancer cell modification, etc.

Questions - contact Curt Bolton, curt.bolton@science.doe.gov

b. Low-Temperature Plasma Science and Engineering for Plasma Nanotechnology

Another current challenge has been identified in plasma assisted material synthesis for improving our current understanding and scientific knowledge in the area of plasma nanotechnology. Specific examples include but are not limited to: plasma-based nanotubes, submicron matters, etc.

Questions - contact Curt Bolton, curt.bolton@science.doe.gov

c. Low-Temperature Plasma Chemistry for a Cleaner Environment

Clean supplies of energy, water and air constitute some of the largest global issues for the near future. Low temperature plasmas offer a possible path to these supplies. Examples include the generation of syngas, as a catalyst for changing CO_2 into carbonates, efficient small scale generation of NH3, and the generation of liquid transportation fuels from CO_2. Low temperature plasmas chemistry also show promise in the area of purification of recycled and polluted water by disinfecting it and degrading organic pollutants. Chemical processing leaves residual toxicity, while ultraviolet processing inefficiently consumes electricity, and neither method degrades all pharmaceuticals. Techniques using plasmas for supplies of clean energy, water and air are sought.

Questions - contact Curt Bolton, curt.bolton@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this topic including plasmas separation technology, plasma assisted combustion, and MHD power generation.

Questions - contact Curt Bolton, curt.bolton@science.doe.gov

REFERENCES:

1. U.S. Department of Energy, 2008, Low-Temperature Plasma Science Workshop: Not Only the Fourth State of Matter but All of Them, Report of the U.S. Department of Energy Office of Fusion Energy Sciences Workshop on Low Temperature Plasmas, March 25-27, p. 52. (http://science.energy.gov/fes/about/~/media/fes/pdf/about/Low_temp_plasma_report_march_2008.pdf)

2. National Research Council, Plasma 2010 Committee, 2007, Plasma Science: Advancing Knowledge in the National Interest, Washington, D.C., The National Academies Press, p. 280, ISBN: 978-0-309-10943-7. (http://www.nap.edu/catalog.php?record_id=11960)

PROGRAM AREA OVERVIEW: OFFICE OF HIGH ENERGY PHYSICS

The goal of the Department of Energy's (DOE or the Department) Office of High Energy Physics (HEP) 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.

The DOE HEP program supports research in three discovery frontiers, namely, the energy frontier, the intensity frontier, and the cosmic frontier. Experimental research in HEP is largely performed by university and national laboratory scientists, usually 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. The Department also has a significant role in the Large Hadron Collider (LHC) at the CERN laboratory in Switzerland. The Fermilab complex includes the Main Injector (which formerly fed the now dormant Tevatron ring), which is used to create high-energy particle beams for physics experiments, including the world's most intense neutrino beam. The Main Injector is undergoing upgrades to support the operation of Fermilab's present and planned suite of neutrino and muon experiments at the Intensity Frontier. A new Fermilab facility in development, called PIP-II (Proton Improvement Plan II) will greatly increase the intensity of proton beams sent to the Main Injector. The SLAC National Accelerator Laboratory and the Lawrence Berkeley National Laboratory are involved in the design of state-of-the-art accelerators and related facilities for use in high-energy physics, condensed matter research, and related fields. SLAC facilities include the three kilometer long Stanford Linear Accelerator capable of generating high energy, high intensity electron and positron beams. The first two kilometers of the linear accelerator are used for the Facility for Advanced Accelerator Experimental Tests (FACET), now undergoing an upgrade called FACET-II. At Argonne National Laboratory, also near Chicago, resides the Argonne Wakefield Accelerator (AWA) facility, which houses two test electron accelerators, one for 15 MeV electrons, and the other for 70 MeV electrons. Experiments focus on two-beam and collinear wakefield acceleration as well as tests of novel accelerator structures and beam-line components. Brookhaven National Laboratory operates the Accelerator Test Facility, which supports accelerator science and technology demonstrations with electron and laser beams. 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. As stewards of accelerator technology for the nation, HEP also supports development of new concepts and capabilities that further scientific and

commercial needs beyond the discovery science mission. 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.

23. ADVANCED CONCEPTS AND TECHNOLOGY FOR PARTICLE ACCELERATORS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The DOE 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. The strategic plan for HEP includes initiatives on the energy and intensity frontiers, relying on accelerators capable of delivering beams of the required energy and intensity. As high energy physics facilities get bigger and more costly, the DOE HEP program seeks to develop advanced technologies that can be used to reduce the overall machine size and cost, and also to develop new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

In many cases the technology sought is closely tied to a specific machine concept which sets the specifications (and tolerances) for the technology. Applicants are strongly encouraged to review the references provided. Applications to subtopics specifically associated with a machine concept that do not closely adhere to the specifications of the machine will be considered non-responsive. For subtopics that are not machine-specific, applicants are strongly advised to understand the state-of- the-art and to clearly describe in the application what quantitative advances in the technology will result.

Grant applications are sought only in the following subtopics:

a. High Gradient High Efficient Collinear Wakefield Acceleration Techniques

Wakefield acceleration in dielectric structures has a potential to become the next generation technology for future linear colliders. Development of advanced beam phase space manipulation techniques and the associated wakefield structures to produce high transformer ratios (TR) are critical to the collinear wakefield concept. The single bunch breakup instability is a major limiting factor for sustainable high gradient wakefield acceleration. At extremely high gradients and potentially required high repetition rate the bulk dielectric and metal cladding of the dielectric fibers experience extreme heat load. This will become critical for stable operation of such dielectric loaded accelerating structures.

Grant applications are sought develop a high energy gain multi-meter long collinear wakefield accelerator that achieves a high efficient transfer of the drive bunch energy to the witness bunch at > 500 MV/m gradient with TR>2; to develop the Beam Break-Up (BBU) control technique to be applied to obtain a stable multi-meter long propagation of the drive and witness bunches; to consider thermal effects related to high GV/m level gradient at THz frequencies and design and optimized the dielectric based structure to the linear collider requirements.

Questions - contact John Boger, john.boger@science.doe.gov

b. Particle Beam Sources (Electron and Ion)

The Office of High Energy Physics is interested in receiving grant applications submitted in response to the following items.

Low Emittance Electron sources for wakefield accelerators. Grant applications are sought for robust electron sources for the external injected main beam of wakefield accelerators. Such electron sources must be capable of producing short bunch low emittance beams satisfying wakefield accelerator operation at THz regime. Low cost and compactness are also preferable considerations.

High Brightness Electron Sources. Grant applications are also sought to demonstrate technologies that support the production of high-peak current (> 5 kA), low-emittance (< 0.15 micrometer) electron bunches (> 100 pC). Novel emittance partitioning concepts are of particular interest, including developing high compression ratio (>20) bunch compressors based on coupled emittance exchangers that suppress effects from coherent synchrotron radiation.

Questions - contact John Boger, john.boger@science.doe.gov

c. Novel Device and Instrumentation Development

New Materials for High Power Target Applications. Grant applications are sought for the development of high-strength, electro-spun targets made from nanostructured ceramic, metal, or carbon. High powered accelerator targets for use by PIP must be able to withstand (1) long-term exposure to high radiation, (2) reduce build-up of internal stresses, and be (3) capable of being manufactured with large surface areas. Electrospinning has yet to produce these materials reliably with high mechanical strength and other properties needed for accelerator targets. The challenge therefore is to produce high-quality electro-spun targets by this method.

Novel Coating Technologies for Neutrino Focusing Horns. Grant applications are sought for novel technologies for the fabrication and characterization of neutrino focusing horns. These horns are situated in the accelerator beam line and are commonly made of aluminum that has a hard coating to prevent erosion, corrosion, and fatigue. The most

successful coating thus far has been an electroless nickel coating. The application of this coating, however, is challenging due to the large size of the horn (4 m x 1 m x 1 m). Anodizing the aluminum surface is another method that produces a coating that has been found effective for reducing corrosion, but less effective for fatigue and erosion. Both coatings eventually fail in the radioactive and corrosive air environment of MW-class proton accelerator beams that shorten the working lifetime of the horn. Alternative methods for the application of an electroless nickel coating that reduce the cost and complexity of the coating process, as well as the volume of chemicals used, are sought. Other coatings that achieve the same goals and can survive in the operational environments of the horn will also be considered.

Magnetic Field and Quality Measurement Instrumentation for a Positron Damping Ring. Grant applications are sought to develop magnetic measurement systems that can determine the center of a magnetic field to within ±10 μm magnetic, and measure field quality, field corrections, and alignment along the curved central path length of the Positron Damping Ring. The variable longitudinal curvature radius of the ring is in the range of 1-2 meters. Instrumentation must be able to make measurements that are consistent with the geometry and requirements of a small positron damping ring magnet lattice such as that shown in the FACET II design report.

Diagnostic Tools for Electron Beam Characterization and Optimization. Grant applications are sought to develop novel diagnostic techniques for electron beam transverse and longitudinal characterization and optimization of the high peak intensity beams such as the FACET-II electron beam (up to 100 kA). Techniques that don't intercept the beam are preferred but others will be considered.

3D Probes for Neutrino Horn Magnetic Field Measurements. Grant applications are sought for small 3D probes to precisely measure magnetic fields used by neutrino horns to focus the charged particles that generate the neutrino beam. Measurement of these fields is complicated by the large size of the devices, the pulsed currents, and safety constraints. This topic seeks fast, compact, 3D probes that can be positioned remotely in large volumes. The appropriate bandwidth must be in excess of 10 kHz, preferably 100 kHz or higher. The probes must be only a few mm in size. The magnetic fields must be simultaneously measured in three degrees and must be truly orthogonal to better than 1 degree. The fields in question are 0.1 G to 3 T. Data acquisition at these high rates is also needed. The devices must not distort the magnetic field.

Residual-Gas Profile Monitors for Intense Beams in Transfer Lines. Grant applications are sought for residual-gas profile monitors for intense beams in transfer lines. Intense (multi-MW) proton beams pose a challenge for beam profile measurements. Solid-based beam-intercepting instrumentation produces unallowable levels of radiation at these high powers. An alternative is to use a zero-or-low mass device such as a residual-gas profile monitor, either through collection of ionization or fluorescence. Challenges are to produce

repeatable, pulse-by-pulse measurements of beam sizes and positions. Typical beam size is 1-2 mm rms, and the required pulse-to-pulse precision is 0.1 mm in position and size.

Magnet Designs for a Small Positron Damping Ring. One of the key features planned for the FACET-II facility at SLAC is the ability to use positrons as part of its experimental research program. Space limitations at the FACET facility require a damping ring no more than 3 meters in diameter. A lattice has been developed for the damping ring, which can be seen in the FACET-II Technical Design Review (see reference below). This innovative lattice requires high strength combined function magnets packed in a dense configuration. Grant applications are sought to develop such magnets, which must meet the following minimal specifications: they must have an on-axis magnetic field greater than 1.44 T with a gap greater than 4.4 cm and a quadrupole gradient greater than 10 T/m. Such magnets could have more general application to positron and electron rings with tightly constrained dimensions.

Grant applications are also sought for the design of high performance electromagnetic and/or permanent quadrupole and sextupole magnets. Mitigation of fringe fields and cross talk are critical design considerations.

Single shot diagnostics of short beam bunches. Grant applications are sought for non-invasive single shot diagnostics of longitudinal and transverse beam bunch profiles (lengths less than tens of microns) of low charge (< 100 pC) and ultra-low emittances (< 0.1 micron).

Questions - contact John Boger, john.boger@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact John Boger, john.boger@science.doe.gov

REFERENCES:

1. Advanced Accelerator Concepts: 15th Advanced Accelerator Concepts Workshop. AIP Conference Proceedings. Vol. 1507. Austin, Texas. June 10-15, 2012. Available at http://proceedings.aip.org/resource/2/apcpcs/1507/1

2. ICFA Beam Dynamics Workshops and Mini-Workshops. Complete listing of workshops and links to proceedings available at http://www-bd.fnal.gov/icfabd/workshops.html;

3. Conference on Applications of Accelerators in Research and Industry. Fort Worth, Texas. August 5-10, 2012. Information and proceedings available at www.caari.com

4. 2012 Beam Instrumentation Workshop (BIW12). Newport News, Virginia. April 15-19. Proceedings available at https://www.jlab.org/conferences/BIW12/

5. T.P. Wangler. (2008). RF Linear Accelerators. Physics Textbook. 2nd ed. Hoboken, New Jersey: Wiley-VCH. ISBN: 978-3527406807. Available at http://www.amazon.com/dp/3527406808

6. R. Raja & S. Mishra. (2010). Applications of High Intensity Proton Accelerators: Proceedings of the Workshop. World Scientific. Batavia, Illinois. ISBN: 978-9814317283. Available at http://www.amazon.com/Applications-High-Intensity-Proton-Accelerators/dp/9814317284

7. A. Chao & M. Tigner. (1999). Handbook of Accelerator Physics and Engineering. World Scientific. River Edge, New Jersey. ISBN: 9-8102-38584. Available at http://www.amazon.com/Handbook-Accelerator-Physics-Engineering-Alex/dp/9810238584

REFERENCES: Subtopic b:

1. Workshop on Energy and Environmental Applications of Accelerators, Edited by Stuart Henderson and Thomas Waite, (2015). http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Energy_Environment_Report_Final.pdf

REFERENCES: Subtopic c:

1. FACET-II Technical Design Report, http://slac.stanford.edu/pubs/slacreports/reports19/slac-r-1072.pdf

2. Measurements of the LCLS laser heater and its impact on the x-ray FEL performance, Z. Huang et al, (2009). SLAC National Accelerator Laboratory, Menlo Park, CA. http://www-public.slac.stanford.edu/scidoc/docMeta.aspx?slacPubNumber=SLAC-PUB-13854

3. Proton Improvement Plan-II. December 2013. Rev. 1.1. http://projectx-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=1232;filename=1.2%20MW%20Report_Rev5.pdf;version=3

4. Hurh, P., et al. "Targetry Challenges at Megawatt Proton Accelerator Facilities." Proceedings of the 4th International Particle Accelerator Conference, THPFI082, (IPAC13, Shanghai). 2013. http://accelconf.web.cern.ch/accelconf/IPAC2013/papers/thpfi082.pdf

5. Effect of Neutron Irradiation on Select MAX Phases, D.J. Tallman, E.N. Hoffman, E.N. Caspi,B.L. Garcia-Diaz, G. Kohse, R.L. Sindelar, M.W. Barsoum, Acta Materialia, 85, 132-143 (2015). http://max.materials.drexel.edu/wp-content/uploads/1-s2.0-S1359645414008477-main.pdf

24. RADIO FREQUENCY ACCELERATOR TECHNOLOGY

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Radio frequency (RF) technology is a key technology common to all high energy accelerators. RF sources with improved efficiency and accelerating structures with increased accelerating gradient are important for keeping the cost down for future machines. DOE-HEP seeks advances directly relevant to HEP applications, and also new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

In many cases the technology sought is closely tied to a specific machine concept which sets the specifications (and tolerances) for the technology. Applicants are strongly encouraged to review the references provided. Applications to subtopics specifically associated with a machine concept that do not closely adhere to the specifications of the machine will be considered non-responsive.

For subtopics that are not machine-specific, applicants are strongly advised to understand the state-of- the-art and to clearly describe in the application what quantitative advances in the technology will result.

a. High Gradient Accelerator Research & Development

Grant applications are sought for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Electron accelerators achieving gradients appreciably greater than >100 MV/m with shunt impedances >100 MOhm/m and fabrication costs below 100 k$/m are sought.

Proton accelerators achieving >10 MV/m are also of interest, as are means for suppressing unwanted higher-order modes and reducing costs for both electron and proton accelerators.

Questions - contact John Boger, john.boger@science.doe.gov

b. Radio Frequency Power Sources and Components

Grant applications are sought for the development of power sources for accelerating cavities operating with 1-5 mA of average beam current in linacs capable of accelerating protons and ions to several GeV. Frequencies of interest include 325 and 650 MHz. Both pulsed and continuous wave (CW) applications are of interest. Examples of systems of interest include, but are not limited to: klystrons, solid state, inductive output, and phase locking magnetron devices; their associated power supplies; and associated low level radio frequency (LLRF) control systems.

Questions - contact John Boger, john.boger@science.doe.gov

c. Low Cost Radio Frequency Power Sources for Accelerator Application

Low cost, highly efficient RF power sources are needed to power accelerators. Achieving power efficiencies of 70% or better, decreasing costs below $2/peak-Watt for short-pulse sources, and below $3/average-kilowatt for CW sources are essential. Sources must phase lock stably (<1 degree RMS phase noise) to an external reference, and have excellent output power stability (<1% RMS output power variation). Device lifetime must exceed 10,000 operating hours. Vacuum-tube based sources should be designed to operate at <100kV beam voltage to improve reliability and reduce cost of required HV systems. Priority will be given to applications that develop RF power sources operating at frequencies that are in widespread use at the large Office of Science accelerators.

For normal conducting accelerators, microsecond-pulsed high-peak-power sources are needed that operate at L-band or higher frequencies. The peak output power of individual sources is flexible, but must be compatible with delivering ~100 MW/meter to compact accelerators. The source must support >0.1% duty factor operation.

For superconducting accelerators, both millisecond-pulsed and CW sources are needed that operate at L-band frequencies. The peak output power of individual sources is flexible, but must be compatible with delivering ~100 kW/meter to high power accelerators. If the source is not CW capable, it must support >5.0% duty factor operation.

Radiofrequency power sources of particular interest include:

- The magnetron, provided it is adapted to include control of output power by, e.g., using a grid, and stable phase control by introducing, e.g., injection locking;
- The Klystron, provided it is adapted to significantly increase power efficiency and reduce cost;
- Solid state power amplifiers, provided the high cost per watt can be significantly reduced.

Applications must clearly articulate how the proposed technology will meet all metrics listed in this section.

Questions - contact John Boger, john.boger@science.doe.gov

d. High Efficiency High Average Power RF Sources

Future high power accelerators will require highly efficient sources of megawatt-class radiofrequency power. R&D to significantly improve the power efficiency of high-average-power (CW or high duty factor) radiofrequency tubes is sought. Net tube power efficiency (including focusing magnet power) must exceed 80%, and average tube power must exceed 100 kW, with a pulse format (peak power, pulse length) that is appropriate for either normal conducting or superconducting accelerators, and an output that is stably phase

locked to an external reference. The proposed device must provide an economical route to producing 1 MW or more of average power by scaling, coherent combination, or both. Priority will be given to applications that develop RF power sources operating at frequencies that are in widespread use at the large Office of Science accelerators.

Questions - contact Eric Colby, Eric.Colby@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact John Boger, john.boger@science.doe.gov

REFERENCES:

1. Abe, D.K. and Nusinovich, G.S., 2006, June 13-17, 2005 AIP Conference Proceedings, High Energy Density and High Power RF: 7th Workshop on High Density and High Power RF, No. 807, Springer Science & Business Media. Kalamata, Greece, ISBN: 0-7354-02981. Available at http://books.google.com/books/about/High_Energy_Density_and_High_Power_RF.html?id=LjZ7xzjAedkC

2. Zgadzaj, R., Gaul, E., and Downer, M., June 10-15, 2012, AIP Conference Proceedings, Advanced Accelerator Concepts Workshop,No. 1507, Austin, TX, available at http://proceedings.aip.org/resource/2/apcpcs/1507/1

3. The 26th International Linear Accelerator Conference (LINAC12), September 9-14, 2012, Tel Aviv, Israel, http://www.linac12.org.il/

4. 2012 IEEE International Power Modulator and High Voltage Conference (IPMHVC 2012), June 3-7, 2012, San Diego, CA, available at http://www.proceedings.com/18149.html

5. Conference on Applications of Accelerators in Research and Industry, August 5-10, 2012, Fort Worth, TX, information and proceedings available at http://inspirehep.net/record/1229546?ln=en

6. For information about RF sources used at the major Office of Science Accelerator facilities, follow the links found at http://science.energy.gov/user-facilities/user-facilities-at-a-glance/

7. Laurent, L, et al., 2011, Experimental Study of RF Pulsed Heating, Physical Review Special Topics – Accelerators and Beams, vol. 14, pp. 041001(1-21), available at http://prst-ab.aps.org/abstract/PRSTAB/v14/i4/e041001

8. Dolgashev, V., et al., 2010, Geometric Dependence of Radio-frequency Breakdown in Normal Conducting Accelerating Structures, Applied Physics Letters, vol. 97, issue 17, pp 171501(1-3), available at http://apl.aip.org/resource/1/applab/v97/i17/p171501_s1

REFERENCES: Subtopic a:

1. Neilson, J., Tantawi, S., and Dolgashev, V. , 2011, Design of RF feed system and cavities for standing-wave accelerator structure, Nuclear Instruments & Methods in Physics Research, Section A (Accelerators, Spectrometers, Detectors and Associated Equipment), vol. 657, issue 1, Menlo Park, CA, pp. 52-54 http://www.researchgate.net/publication/251525400_Design_of_RF_feed_system_and_cavities_for_standing-wave_accelerator_structure

REFERENCES: Subtopic b:

1. Proton Improvement Plan-II, Rev. 1.1, December 2013, http://projectx-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=1232;filename=1.2%20MW%20Report_Rev5.pdf;version=3

2. Collins, G., 1948, Microwave Magnetrons, Radiation Laboratory Series 6, McGraw-Hill, available at http://www.amazon.com/Microwave-Magnetrons-Radiation-Laboratory-6/dp/B000JDA2FG/ref=sr_1_2?s=books&ie=UTF8&qid=1372448127&sr=1-2&keywords=Microwave+magnetrons

25. LASER TECHNOLOGY R&D FOR ACCELERATORS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Lasers are used or proposed for use in many areas of accelerator applications: as drivers for novel accelerator concepts for future colliders; in the generation, manipulation, and x-ray seeding of electron beams; in the generation of electromagnetic radiation ranging from THz to gamma rays; and in the generation of neutron, proton, and light ion beams. In many cases ultrafast lasers with pulse lengths well below a picosecond are required, with excellent stability, reliability, and beam quality. With applications demanding ever higher fluxes of particles and radiation, the driving laser technology must also increase in repetition rate—and hence average power—to meet the demand. Please note that proposals submitted in this topic should clearly articulate the relevance of the proposed R&D to HEP's mission.

This topic area is aimed at developing technologies for (1) ultrafast lasers capable of high average power (kilowatt-class) operating at the high electrical-to-optical efficiency (>20%), and (2) novel nanosecond-pulse lasers needed for accelerator applications.

Accelerator applications of ultrafast lasers call for one of the following four basic specifications:

	Type I	Type II	Type III	Type IV
Wavelength (micron)	1.5-2.0	0.8-2.0	2.0-5.0	2.0-10.0
Pulse Energy	3 microJ	3 J	0.03–1 J	300 J
Pulse Length	300 fs	30–100 fs	50 fs	100–500 fs
Repetition Rate	1–1300 MHz	1 kHz	1 MHz	100 Hz

Average Power	Up to 3 kW	3 kW	3 kW and up	30 kW
Energy Stability	<1 %	<0.1%	<1%	<1%
Beam Quality	M^2<1.1	Strehl>0.95	M^2<1.1	M^2<1.1
Wall-plug Efficiency	>30%	>20%	>20%	>20%
Pre-Pulse Contrast	N/A	$>10^{-9}$	N/A	$>10^{-9}$
CEP-capable	Required	N/A	Required	N/A
Optical Phase Noise	<5°	N/A	<5°	N/A
Wavelength Tunability Range	0.1%	0.1%	10%	0.1%

Longer-pulse lasers are finding increasing application in the control and diagnosis of proton and H-minus beams. Near IR lasers are used in a variety of applications ranging from partial neutralization of H-minus beams (0.75 eV binding energy) for diagnostics to total neutralization (for notching and phase space sculpting). UV lasers are used for stripping neutral hydrogen beams (13.6 eV binding energy) by resonantly exciting the atom, then Lorentz stripping the more loosely bound electron in a strong magnetic field. As proton machines move steadily into the megawatt beam power range, the need for non-intercepting techniques to control and diagnose such beams will motivate increased use of lasers, and the increased duty factor of such machines will motivate increases in the average power of lasers used for this purpose.

Grant applications are sought to develop lasers and laser technologies for accelerator applications only in the following specific areas:

a. Cost Reduction of Ultrafast Fiber Laser Components

One route to achieving high peak and average power is to coherently combine the output of many (e.g. thousands of) ultrafast fiber lasers. In this case, power efficiency, beam quality, compactness, reliability, stability, and low cost of the individual lasers are each essential. Note that components and subsystems must be developed for propagating and amplifying high-quality (M^2<1.2) ultrafast (<100 fs) laser pulses. Proposals that develop integrated subsystems (e.g. a single-channel fiber amplifier chain, or high power WDM components) will be given highest priority, although proposals for individual components that offer revolutionary gains in any of the performance characteristics above will also be welcomed. While Yb:fiber components are highest priority, Tm:fiber components are also encouraged.

Questions - contact Eric Colby, eric.colby@science.doe.gov

b. Ceramic-Based Optical Materials

To achieve high average power and high peak power will require new gain materials with superior damage threshold, dopant density, optical bandwidth, and thermal properties. Sintered laser gain materials for ultrafast lasers offer promise of achieving many of these characteristics. Candidate materials must achieve broad bandwidth (>10%), high peak

power (>10 TW), and endure sustained high average power (>kW) operation. Proposals to develop new laser gain materials and/or advanced sintering techniques for producing very high quality laser gain media are sought. Proposals to develop techniques capable of producing precisely controlled spatial gain profiles are strongly encouraged.

Questions - contact Eric Colby, eric.colby@science.doe.gov

c. High Reliability Arbitrary Pulse Pattern Laser Amplifiers for H- Beam Control and Diagnostics

Grant applications are sought for high reliability, variable pulse-pattern, high repetition-rate, intense near-IR lasers for neutralizing, notching, tailoring, and diagnosing H-minus beams. The primary challenges of such systems are (1) robustness and reliability, (2) stable operation despite arbitrary bunch patterns and widely variable output power, and (3) compactness.

In the typical application, the laser will be installed and operated in an accelerator environment, and will be required to operate with greater than 99% uptime. The laser must be engineered to allow reliable remote operation, requiring no more than one hands-on intervention per day to maintain operating parameters. A compact configuration (e.g. less than 1 m x 1 m x 1 m) with suitable environmental control and EMI shielding is required. The amplifier will be seeded by a computer-controlled external source that provides arbitrary pulse bursts at up to 60 Hz that last up to 100 microseconds, with individual pulses occurring at a rate of 500 kHz. The individual pulses are gated out of a 200 MHz pulse train that is phase-locked to an external microwave reference. Similarly, the 500 kHz and 60 Hz substructures are controlled by an external timing system and are variable. The pulse energy and pulse length are each variable, ranging up to 2 mJ in a 2 nanosecond duration flat-top micro-pulse. Up to 3000 pulses per second from the 200 MHz pulse train may be amplified to full energy, requiring an average output power of up to 6 W. Output must be to free-space, with an $M^2<1.5$.

While current applications call for very modest average power, within the next decade systems capable of much higher duty factor operation and consequently much higher average laser power (exceeding 3 kW) will be needed. Therefore, priority will be given to applications that not only meet the parameters for the first-generation systems, but can demonstrate a clear technology path to multi-kW operation over the next 5-10 years.

Questions - contact Eric Colby, eric.colby@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Eric Colby, eric.colby@science.doe.gov

REFERENCES:

1. Workshop on Laser Technology for Accelerators. January 23-25, 2013, http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Lasers_for_Accelerators_Report_Final.pdf

2. Zgadzaj, R., Gaul, E., and Downer, M., June 10-15, 2012, Advanced Accelerator Concepts: 15th Advanced Accelerator Concepts Workshop, AIP Conference Proceedings. Vol. 1507, Austin, available at http://scitation.aip.org/content/aip/proceeding/aipcp/1507.

26. SUPERCONDUCTOR TECHNOLOGIES FOR PARTICLE ACCELERATORS

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

Superconducting materials are widely used in particle accelerators to create large continuous electric and magnetic fields for beam acceleration and manipulation. Advanced R&D is needed in support of this research in high-field superconductor, superconducting magnet, and superconducting RF technologies. This topic addresses only those superconducting magnet development technologies that support accelerators, storage rings, and charged particle beam transport systems, and only those superconducting wire technologies that support long strand lengths suitable for winding magnets without splices.

Grant applications are sought only in the following subtopics:

a. High-Field Superconducting Wire and Cable Technologies for Magnets

Grant applications are sought to develop new or improved superconducting wire for high field magnets that operate at 16 Tesla (T) field and higher. Proposals should address production scale (> 3 km continuous lengths) wire technologies at 16 to 25 T and demonstration scale (>1 km lengths) wire technologies at 25 to 50 T. Current densities should be at least 400 amperes per square millimeter of strand cross-section (often called the engineering current density) at the target field of operation and 4.2 K temperature. Tooling and handling requirements restrict wire cross-sectional area to the range 0.4 to 2.0 square millimeters, with transverse dimension not less than 0.25 mm. Vacuum requirements in accelerators and storage rings favor operating temperatures below 20 K, so high-temperature superconducting wire technologies will be evaluated only in this temperature range. Primary conductors of interest are the HTS materials $Bi_2Sr_2CaCu_2O_8$ (Bi-2212), and (RE)$Ba_2Cu_3O_7$ (ReBCO) that are engineered for high field magnet applications; new architectures or processing methods that significantly lower the cost of Nb_3Sn wire may also be of interest. Other materials may be considered if high field performance, length, and cost equivalent to these primary materials can be demonstrated. All grant applications must result in wire technology that will be acceptable for accelerator magnets, including not only the operating conditions mentioned above, but also delivery of a

sufficient amount of material (1 km minimum continuous length) for winding and testing small magnets.

New or improved wire technologies must demonstrate at least one of the following criteria in comparison to present art: (1) property improvement, such as higher current density or higher operating field; (2) improved tolerance to property degradation as a function of applied strain; (3) reduced transverse dimensions of the superconducting filaments (sometimes called the effective filament diameter), in particular to less than 30 micrometers at 1 mm wire diameter, with minimal concurrent reduction of the thermal conductivity of the stabilizer or strand critical current density; (4) innovative geometry for ReBCO materials that leads to lower magnet inductance (cables) and lower losses under changing transverse magnetic fields; (5) correction of specific processing flaws (not general improvements in processing), to achieve properties in wires of more than 1 km length that are presently restricted to wire lengths of 100 m or less; (6) significant cost reduction for equal performance in all regards, especially current density and length.

Grant applications are also sought to develop innovative high current cable designs and processing technologies. Approaches of interest include Nb_3Sn cables optimized for 14 – 16T dipole magnets, methods to use stranded conductors with high aspect ratio to make efficient magnet cables and methods to adapt tape geometries to particle accelerator applications.

Questions - contact Ken Marken, ken.marken@science.doe.gov

b. Superconducting Magnet Technology

Grant applications are sought to develop: (1) very high field (20 T and above) dipole magnets; (2) designs and prototypes for HTS/LTS hybrid solenoid systems capable of achieving 30 to 40T axial fields and warm bores with a diameter ≥2 cm, which are of interest for final cooling of a muon beam prior to acceleration and injection into a collider storage ring, but also have broader application; (3) alternative designs – to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets – that may be more compatible with the more fragile Nb_3Sn and HTS/high-field superconductors; (4) fast cycling HTS magnets capable of operation at or above 4T/s; (5) reduction in magnetization induced harmonics in HTS magnets; (6) improved magnet designs and industrial fabrication methods for magnets, such as welding and forming, that lead to lower costs; (7) quench protection in HTS magnets and HTS/LTS hybrid magnets; (8) iron-dominated magnets with HTS coils. In spite of the significant progress of the new HTS materials in the recent years, there is still an open gap to implement these materials in accelerator magnets. An iron-dominated magnet could fill this gap. The proposed magnet should have circular coils and low coil peak field, a configuration favorable for the conduction cooling. Such a coil should be wound inside an aluminum channel to facilitate conductive cooling. The magnets should operate in a temperature range between 20 K and 80 K. Potential applications include linear

accelerators, beam transport lines as an alternative solution to the room temperature, permanent, or superconducting NbTi magnets.

Questions - contact Ken Marken, ken.marken@science.doe.gov

c. Superconducting RF Materials & Cavities

Materials and Fabrication Technologies for SRF Cavities – Material properties, surface features, processing procedures, and cavity geometry can have significant impact on the performance of superconducting radio-frequency (SRF) accelerator cavities. Grant applications are sought to develop (1) new raw materials streams, such as those utilizing large-grain Nb ingot slices; (2) new or improved SRF cavity fabrication techniques, such as seamless and weld-free approaches; (3) SRF cavity fabrication techniques that reduce use of expensive metals such as niobium while achieving equivalent performance as bulk niobium cavities; (4) new or improved bulk processing technologies, such as mechanical or plasma polishing; (5) new or improved final surface preparation and protection technologies; (6) techniques to coat copper (or other) cavity substrates with SC thin-film materials with RF properties that meet or exceed those of bulk Nb and/or enable operation at 4 K or above; (7) develop technology for Nb_3Sn coating for multi-cell Nb cavities in frequency range from 650 to 1300 MHz, and demonstrate $Q_0 > 10^{10}$ at 4 K at the gradient >20 MV/m; (8) integrated flexible temperature mapping system for elliptical SRF cavities of different shapes and frequencies from 650 MHz to 3.9 GHz; (9) new methods, techniques and components for SRF cavity Q_0 measurements including (i) reliable RF methods and components for Q_0 measurements for heavily overcoupled cavities, (ii) inexpensive high-quality, low and medium power RF components (directional couplers, circulators, etc.) in frequency range from 162.5 MHz to 3.9 GHz; (10) low-cost, frequency agile, self-calibrating digital RF control system capable of more accurate SRF cavity Q_0 measurements over a wide range of frequencies (70 MHz to 6 GHz) and cavity couplings; (11) algorithms and apparatus for narrow-band SC cavity resonance control in pulsed and CW regimes in 162.5 MHz – 1.3 GHz frequency range. Operating together with LLRF system, the methods should achieve 10^{-4} amplitude and 10^{-2} deg phase stability.

SRF Cavities – Grant applications are sought for the development of superconducting radiofrequency cavities for acceleration of proton and ion beams, with relativistic betas ranging from 0.1 to 1.0. Frequencies of current interest include 325, 650, 1300 MHz and S-band to 4 GHz. Continuous wave (CW) cavities are of the greater interest, although pulsed cavities could also be supported. Accelerating gradients above 15 MV/m, at Q0 in excess of 2×10^{10} (CW), and above 25 MV/m at Q_0 in excess of 1×10^{10} (pulsed) are desirable. Topics of interest include: (1) cavity fabrication alternatives to electron beam welding, including for example hydroforming and automatic TIG or laser welding of cavity end groups; (2) other cavity and cryomodule cost reduction methods; (3) cw power couplers at >50kW; (4) fast tuners for microphonics control; (5) higher order mode suppressors, including extraction of HOM power via the main power coupler and with photonic band gap cavities; (6) ecologically friendly or alternative cavity surface processing methods; (7) alternatives to

high pressure rinsing that would allow in-situ cleaning of cavities to control field emission; (8) high resolution tomographic x-rays of electron beam welds in cavities; (9) methods to controllably dope or alloy the near surface for performance enhancement; (10) conduction cooled SRF cavities that can operate using cryo-coolers; (11) SRF dressed cavities in the frequency range from 650 MHz to 1.3 GHz with improved mechanical stability having Lorentz Force detuning less than 0.5-0.6 Hz/$(MV/m)^2$, and frequency sensitivity versus helium pressure variation less than 5 Hz/mbar; (12) a novel superconducting RF cavity for high-intensity proton synchrotrons, e.g. the Fermilab Main Injector (MI). The cavity should be tunable in the frequency range of 52.617-53.104 MHz. To mitigate beam loading effects, it should have very low R/Q: 3 - 5 Ohms would be desirable. The cavity should provide accelerating voltage of 1 - 2 MV to accelerate about 4 A proton beam in the MI; (13) the development of improved and lower cost magnetic shielding material for SRF cavities.

Questions - contact Ken Marken, ken.marken@science.doe.gov

d. Cryogenic and Refrigeration Technology Systems

Grant applications are sought for (1) high thermal conductivity materials (better than 104 W/(K·m at 4 K) for use in cryogenic environments; (2) the development of wireless or serial optical technologies for thermal, voltage, and pressure measurements in cryogenic environments; (3) the development of simple, robust, high power (≥10 W at 4 K) cryo-coolers to enable stand-alone SRF cavity and SC magnet applications for HEP and Industry

Questions - contact Ken Marken, ken.marken@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Ken Marken, ken.marken@science.doe.gov

REFERENCES: Subtopic a:

1. Larbalestier, D. et al., 2014, "Isotropic round-wire multifilament cuprate superconductor for generation of magnetic fields above 30 T", Nature Materials V.13, p. 375. http://www.nature.com/nmat/journal/v13/n4/full/nmat3887.html?message-global=remove

2. Maeda, H. and Yanagisawa, Y., Recent Developments in High-Temperature Superconducting Magnet Technology (Review), 2014 IEEE Transactions on Applied Superconductivity, vol. 24, no. 3, 4602412. http://ieeexplore.ieee.org/document/6649987/?reload=true

3. Todesco, E. et al., 2014, "Dipoles for High-Energy LHC", IEEE Transactions on Applied Superconductivity, V.24, no. 3, 4004306. https://arxiv.org/ftp/arxiv/papers/1108/1108.1619.pdf

4. Balachandran, U., et al., 2014, Advances in Cryogenic Engineering Materials: Transactions of the Cryogenic Engineering Conference, Anchorage AK, vol. 60, American Institute of Physics (AIP), New York City, NY, ISBN: 978-0-7354-1204-0, available at http://scitation.aip.org/content/aip/proceeding/aipcp/1574

5. Scanlan, R., et al., 2004, "Superconducting Materials for Large Scale Applications", Proceedings of the IEEE, vol. 92, issue 10, pp. 1639-1654, available at https://www.researchgate.net/publication/2986363_Superconducting_materials_for_large_scale_applications

6. Track, E., et al., August 10-15, 2014, The 2014 Applied Superconductivity Conference, IEEE Transactions on Applied Superconductivity, vol. 25 no. 3, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7104225

REFERENCES: Subtopic b:

1. The Twenty-third International Conference on Magnet Technology, July 14-19, 2013, IEEE Transactions on Applied Superconductivity. vol. 24, no. 3, ISSN: 1051-8223, Boston, MA Available at http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=6594876

2. Track, E., et al., August 10-15, 2014, The 2014 Applied Superconductivity Conference, IEEE Transactions on Applied Superconductivity, vol. 25, no. 3, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7104225

3. Palmer, R.B., Fernow, R.C., and Lederman, J., 2011, Muon Collider Final Cooling in 30-50 T Solenoids, Proceedings of the 2011 Particle Accelerator Conference (PAC2011), New York, NY, http://accelconf.web.cern.ch/AccelConf/PAC2011/papers/thobn2.pdf

4. Shiroyanagi, Y., et al., 2012, 15+ T HTS Solenoid for Muon Accelerator Program, Proceedings of the IPAC2012, New Orleans, LA, http://accelconf.web.cern.ch/AccelConf/IPAC2012/papers/thppd048.pdf

5. Schwartz, J., 2008, High Field Superconducting Solenoids via High Temperature Superconductors, IEEE Transactions on Applied Superconductivity, vol. 18, no. 2, http://ieeexplore.ieee.org/document/4493275/

REFERENCES: Subtopic c:

1. A. Gurevich., 2012, "Superconductivity Radio-Frequency Fundamentals for Particle Accelerators." Rev. Accel. Sci. Technol. 5, 119-146. http://www.nature.com/articles/srep17821

2. A. Grassellino, A. Romanenko, et al., 2013, "Nitrogen and argon doping of niobium for superconducting radio frequency cavities: a pathway to highly efficient accelerating structures". Supercond. Sci. Technol. V.26, 10200. https://arxiv.org/ftp/arxiv/papers/1306/1306.0288.pdf

3. Geng, R.L., et al., May 12-16, 2003, First RF Test at 4.2 K of a 200 MHz Superconducting Nb-Cu Cavity, Proceedings of the 2003 Particle Accelerator Conference (PAC2003), vol 2, pp. 1309-1311, available at http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1289688&isnumber=28710

4. Singer, W., July 15, 2006, Seamless/bonded niobium cavities. Physica C: Superconductivity, Proceedings of the 12th International Workshop on RF Superconductivity, vol. 441, issues 1-2, pp. 89-94, available at https://accelconf.web.cern.ch/accelconf/SRF2005/papers/mop10.pdf

5. Bousson, S., et al., March 27-April 2, 1999, An Alternative Scheme for Stiffing SRF Cavities by Plasma Spraying, Proceedings of the 1999 Particle Accelerator Conference, vol. 2, pp. 919-921, available at http://ieeexplore.ieee.org/document/795400/

6. Dzyuba, A., Romanenko, A., and Cooley, L.D., 2010, Model for Initiation of Quality Factor Degradation at High Accelerating Fields in Superconducting Radio-frequency Cavities, Superconductor Science and Technology, vol. 23, issue 12, article ID: 125011, available at http://arxiv.org/abs/1007.2561

7. J. Dey and I. Kourbanis, "A New Main Injector Radio Frequency System For 2.3 MW Project X Operations," Proc. of PAC 2011, NY. http://accelconf.web.cern.ch/accelconf/PAC2011/papers/tup131.pdf

REFERENCES: Subtopic d:

1. Weisend, J.G. II, et al., 2014, Advances in Cryogenic Engineering: Transactions of the Cryogenic Engineering Conference, Anchorage, AK, Vol. 59, American Institute of Physics (AIP), New York, NY, ISBN: 978-0-7354-1201-9, available at http://scitation.aip.org/content/aip/proceeding/aipcp/1573

2. Track, E., et al., August 10-15, 2014, The 2014 Applied Superconductivity Conference, IEEE Transactions on Applied Superconductivity, vol. 25, no. 3, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7104225

REFERENCES: Subtopic e:

1. Balachandran, U., et al., 2014, Advances in Cryogenic Engineering Materials: Transactions of the Cryogenic Engineering Conference, Anchorage AK, vol. 60, American Institute of Physics (AIP), New York City, NY, ISBN: 978-0-7354-1204-0, available at http://scitation.aip.org/content/aip/proceeding/aipcp/1574

2. Track, E., et al., August 10-15, 2014, The 2014 Applied Superconductivity Conference, IEEE Transactions on Applied Superconductivity, vol. 25, no. 3, http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7104225

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

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

High Energy Physics experiments require advanced electronics and systems for the recording, processing, storage, distribution, and analysis of experimental data. High-priority future experiments in the DOE Office of High Energy Physics portfolio need advances that can benefit from small business contributions. These experiments include those planned for the High Luminosity (HL) Upgrade of the Large Hadron Collider (www.cern.ch) or potential future High Energy Colliders, Neutrino Experiments including those sited deep underground (e.g., www.dunescience.org), next generation direct searches for dark matter, and astrophysical surveys to understand cosmic acceleration, including Cosmic Microwave Background experiments.

We seek small business industrial partners to advance the state of the art and/or increase cost effectiveness of instrumentation needed for the above experiments and for the wider HEP community. Specific technical areas are given in the subtopics below. These are areas where experimental needs have been defined and shortcomings of existing technology identified. R&D seeking new technology will typically be in progress at DOE national laboratories and/or DOE-funded universities. While the subtopics offer initial guidance about specific technology areas, the scientists involved are the best source of detailed information about requirements and relevance to the experimental programs listed above. Applicants are therefore urged to make early contact with lab and university scientists in order to develop germane proposals. Clear and specific relevance to high energy physics programmatic needs is required, and supporting letters from lab and university scientists are an excellent way to show such relevance. Direct collaboration between small businesses and national labs and universities is strongly encouraged. For referral to lab and university scientists in your area of interest contact: Helmut Marsiske, helmut.marsiske@science.doe.gov. DOE also expects all applicants to address commercialization opportunities for their product or service in adjacent markets such as medicine, homeland security, the environment and industry.

Grant applications are sought in the following subtopics:

a. Special Purpose Integrated Circuits for Detectors at High Energy Colliders

Particle physics detectors make heavy use of application specific integrated circuits (ASICs), which are designed by engineers at national laboratories and universities and fabricated through commercial foundries. ASICs must meet special requirements that typically preclude the use of commercial off-the-shelf components, such as high total dose radiation tolerance. We are interested in IP blocks and design methodologies that are compatible with radiation hardness and other special requirements. Functionalities needed include low-voltage high-speed I/O, digital signal processors, data compression, error correction, design for test circuits, etc. Circuits using 130nm and 65nm CMOS nodes are of interest for HL-LHC

upgrades. Radiation hard versions of existing commercial IC's are also of interest (see subtopic d). Low-cost prototyping and ways to reduce mask costs are also of interest.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

b. Special Purpose Integrated Circuits for Large Cryogenic Detectors

For large cryogenic detectors such as DUNE it will be desirable to place electronics within the cryogenic volume. This will make access impossible throughout the useful lifetime of the detector of about 20 years. While the analog electronics benefit from a fundamental reduction in intrinsic noise due to the low temperature, CMOS digital logic may have a shortened lifetime due to hot electron effects that arise due to the increased carrier velocities. Manufacturers typically characterize the operation of their parts only to -40C. It is therefore unlikely that off-the-shelf parts will be used at noble liquid temperatures due to the lifetime uncertainty even if they are found to work. Instead there is a strong interest in developing ASICs in commercial processes. Complex digital functions will require digital logic synthesis. Digital libraries must therefore be characterized and possibly modified for cryogenic operation. Partnerships between lab/university researchers and small business could probably best accomplish this goal. Development and testing digital library timing files for sub-micron integrated circuit processes at temperatures below -100C is of interest. Design and characterization of digital library parts in a 65nm CMOS process for long lifetime at temperatures below -100C are of interest.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

c. Fabrication of Custom Real Time Massively Parallel Trigger Processors for Detectors at High Energy Colliders

Many next-generation scientific experiments will be characterized by huge quantities of data, taken at high rates, from which scientists will have to unravel the underlying physical processes. In most cases, large backgrounds will overwhelm the physics signal of interest. Since the quantity of data that can be stored for later analysis is limited, real-time event selection is imperative to retain interesting events while rejecting background signals.

For example, the silicon-based tracking trigger system for the high luminosity LHC will have to process in real time about 100 Tbps data with few micro-seconds processing latency, to analyze billions of proton-proton collisions every second. This requires extremely high bandwidth data communication as well as massive pattern recognition power. Current technology cannot be scaled in a simple manner to accommodate trigger demands at high-luminosity LHC. Significant improvements or breakthroughs will be needed. Proposals are sought for new technology to significantly improve real time high speed low latency data communication, as well as state of the art fast pattern recognition capability. Examples include (but are not limited to) board or module designs with multi Tbps interface capability, PCB design technologies that are compatible with next-generation 100G full-mesh backplane or beyond, technology to integrate modern FPGAs directly with custom

ASIC chips dedicated for fast pattern recognition, and stacked content addressable memory based pattern recognition associative memory using advanced 3D IC technology.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

d. Radiation-Hard High Bandwidth Data Transmission for Detectors at High Energy Colliders

Detector data volumes at the High Luminosity LHC will be nearly 100 times more than today. Single subdetectors will have to transmit 10's to 100's of Tb/s. While commercial off the shelf data transmission solutions will deliver the needed performance in the near future, these products cannot be used in HL-LHC for two main reasons: they will not function in a high radiation environment, and they are in general too massive to be placed inside detectors, where added mass degrades the measurements being made. Two main industrial developments are therefore of interest: very low mass, high bandwidth electrical cables, and radiation hard optical transceivers.

Electrical cables may be twisted pair, twinax, etc., with as low as possible mass (and therefore small size) while compatible with multi-Gbps per lane transmission over distances up to 6m. Cable fabrication using aluminum, copper clad aluminum, or non-metallic conductors (such as CNT thread), is of interest. Many dielectrics are not radiation hard, so fabrication with non-standard dielectrics is important.

Optical transceivers in the range 40 to 100 Gbps will be needed. Many off the shelf commercial products meet or exceed the required bandwidth, but contain circuits that fail when exposed to ionizing radiation. Radiation hardened versions of commercial transceivers (or equivalent) are therefore of interest, where radiation hardness is achieved without adding mass or increasing size, for example by design changes to the integrated circuits used.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

e. High Density Chip Interconnect Technology

The demands on silicon particle tracking detectors in terms of pixel size, mass budget, data rate, and front-end processing are increasing. Grant applications are sought for the development of new technologies for reducing cost while increasing the density of interconnection of pixelated sensors to readout electronics by enhancing or replacing solder bump-based technologies. Development of cost-effective technologies to connect arrays of thinned integrated circuits (< 50 microns, with areas of ~2x2 cm^2) to high-resistivity silicon sensors with interconnect pitch of 50 microns or less are of interest. Technologies are sought that can minimize dead regions at device edges and/or enable wafer-to-wafer interconnection, by utilizing 3D integration with through-silicon vias or other methods.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

f. Radiation Hard CMOS Sensors for Detectors at High Energy Colliders

Silicon detectors for high energy physics are currently based on hybrid technology, with separately fabricated diode strip or pixel sensors and CMOS readout chips. As larger area detectors are required for tracking and also for new applications such as high granularity calorimetry, lower manufacturing cost is needed. Monolithic Active Pixel Sensors (MAPS) in CMOS technology have the potential for low cost, of order $0.1M or less per square meter of instrumented area. For use in high energy physics, detectors must withstand both ionizing and displacement damage radiation, and they must have fast signal collection and fast readout. Radiation tolerance in the range 10 to 1000 Mrad and 1E14 to 2E16 neutron equivalent fluence is of interest. Charge collection time of 20ns or less is of interest. Fabrication of CMOS sensors on high resistivity silicon wafers is of interest to meet these goals. MAPS devices with fast readout (frame rate of 1MHz or higher for 0.1% occupancy frames), as well as passive diode sensors fabricated on 8" or 12" wafers in a CMOS line are of interest. Reticle stitching technology may allow fabrication of large format sensors with low cost.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

g. Large-Area Silicon-Based Sensors for Precise Tracking and Calorimetry

Next generation collider experiments will require finely segmented silicon-based tracking and calorimetry detectors which may cover 100's of square meters. These are typically based on wafer- scale high resistivity silicon diode arrays with 100-300 micron thick fully depleted active regions. Arrays based on tiled CMOS sensors with thin active regions are also candidates. Grant applications are sought for the development of silicon diode-based sensors utilizing lower cost per unit area fabrication technologies. These may include sensors based on large (8" or beyond) wafer diameter, simplified processing, or tiling or stitching technologies. Desired properties include high yield for wafer scale sensors, radiation hardness, thinning to the hundred micron-level with backside ohmic contacts, ten micron-level resolution capability for tracking detectors, and low cost in large volumes.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

h. Radiation Hard, Low Mass IC Power and High Voltage Delivery Circuits for Detectors at High Energy Colliders

Future collider experiments will require high efficiency, low mass, power converters that are radiation hard, have low radiated noise, and can operate in a magnetic field. Novel circuits or systems are sought that utilize high frequency DC-DC converters, GaN transistors, compact coil designs, serial powering schemes or other low loss power transmission designs that can deliver significant power to modern ICs that operate at approximately one volt supply levels. Conversion ratios of 4 or higher are needed in order to sufficiently reduce the mass of power delivery wiring needed. In addition, static on/off switching of low current, high voltage (1KV) is of interest.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

i. Frequency Multiplexed DAQ Systems Motivated by Cosmic Microwave Background Detectors

Future CMB experiments will have large focal plane arrays with ~100k superconducting detector elements for optical, near-IR, millimeter and microwave astronomical surveys. Grant applications are sought for the development of data acquisition systems for these arrays and for detectors needing similar systems. Areas of development include low-noise cryogenic amplifiers (HEMT, SQUID, Parametric, etc.), high-density cryogenic interconnects, high-frequency superconducting flex circuits, and specialized electronics for processing large numbers of frequency domain multiplexed RF signals.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

j. Electronic Tools for Picosecond Timing

High precision timing measurements in next generation detectors will require the development of circuitry to measure time to 1 psec or better, to digitize waveforms at above 10Gs/s. In addition, a method to distribute a stable reference clock with jitter of 5 ps of less and precise frequency stabilization is needed. Such a clock system needs to distribute the clock to multiple detector components distributed by distances of order ten to twenty meters. Custom radiation-hard ASIC devices will eventually be needed for many such high precision uses, but non-radiation hard demonstration systems meeting psec or sub-psec sensitivity and stability are of immediate interest.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

k. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

REFERENCES:

1. Topical Workshop on Electronics for Particle Physics (TWEPP14), September 22-26, 2014, Aix en Provence, France, https://indico.cern.ch/event/299180/.

2. Nessi, M., et al., February 3-5, 2010, WIT2010 Workshop on Intelligent Trackers, Journal of Instrumentation, Berkeley, CA, available at http://iopscience.iop.org/1748-0221/focus/extra.proc7.

3. 21th International Conference on Computing in High Energy and Nuclear Physics (CHEP), April 13-17, 2015, Okinawa, Japan, https://indico.cern.ch/event/304944/

4. 13th Pisa Meeting on Advanced Detectors, May 24-30, 2015, La Biodola, Isola d'Elba, Italy. https://indico.cern.ch/event/359839/

5. International Conference on Technology and Instrumentation in Particle Physics 2014 (TIPP2014), June 2-6, 2014, Amsterdam, The Netherlands, http://www.tipp2014.nl/index.html

6. 19th Real-Time Conference, May 26-30, 2014, Nara, Japan, http://rt2014.rcnp.osaka-u.ac.jp/

7. 13th Vienna Conference on Instrumentation, February 11-15, 2013, Vienna, Austria, http://vci.hephy.at

28. HIGH ENERGY PHYSICS DETECTORS AND INSTRUMENTATION

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

High Energy Physics experiments require specialized detectors for particle and radiation detection. High-priority future experiments in the DOE Office of High Energy Physics portfolio need advances that can benefit from small business contributions. These experiments include those planned for the High Luminosity (HL) Upgrade of the Large Hadron Collider (www.cern.ch) or potential future High Energy Colliders, Neutrino Experiments including those sited deep underground (e.g., www.dunescience.org), next generation direct searches for dark matter, and astrophysical surveys to understand cosmic acceleration, including Cosmic Microwave Background experiments.

We seek small business industrial partners to advance the state of the art and/or increase cost effectiveness of detectors needed for the above experiments and for the wider HEP community. Specific technical areas are given in the subtopics below. These are areas where experimental needs have been defined and shortcomings of existing technology identified. Improvements in the sensitivity, robustness, and cost effectiveness are sought. R&D towards these ends will typically be in progress at DOE national laboratories and/or DOE-funded universities. While the subtopics offer initial guidance about specific detector areas, the scientists involved are the best source of detailed information about requirements and relevance to the experimental programs listed above. Applicants are therefore urged to make early contact with lab and university scientists in order to develop germane proposals. Clear and specific relevance to high energy physics programmatic needs is required, and supporting letters from lab and university scientists are an excellent way to show such relevance. Direct collaboration between small businesses and national labs and universities is strongly encouraged. For referral to lab and university scientists in your area of interest contact: Helmut Marsiske, helmut.marsiske@science.doe.gov. DOE also expects all applicants to address

commercialization opportunities for their product or service in adjacent markets such as medicine, homeland security, the environment and industry.

Grant applications are sought in the following subtopics:

a. Lower Cost, Higher Performance Visible/UV Photon Detection

Detectors for particle physics need to cover large areas with highly sensitive photodetectors. Experiments require combinations of the following properties:

- Large photosensitive area, compatible with cryogenic and/or high pressure operation, and built with low-radioactivity materials for neutrino and dark matter detectors.
- Fast response, radiation hardness, magnetic field compatibility, and high quantum efficiency for LHC and intensity frontier experiments
- Low cost and high reliability

Technologies using modern manufacturing processes and low cost materials are of interest. These include use of semiconductor-based avalanche photodiodes (APD) and Geiger mode APD arrays, SiPM arrays, large area microchannel plate-based systems, new photocathode materials, and high volume manufacturing of large-area, ultra clean, sealed vacuum assemblies.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

b. Ultra-Low Background Detectors and Materials

Experiments searching for extremely rare events such as nuclear recoils from WIMP dark matter particles or neutrinoless double beta decays require that the detector elements and the surrounding support materials exhibit extremely low levels of radioactivity. The presence of even trace amounts of radioactivity in or near a detector induces unwanted effects. New instruments and techniques are needed and may include: 1) Instruments to measure ultra-low-backgrounds of gamma, neutron and alpha particles; 2) Improvements in the ability to measure and control radon or surface contamination; 3) Development of ultra-radio-pure materials for use in detectors; and 4) Manufacturing methods and characterization of ultra-low- background materials.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

c. Picosecond Timing Particle Detectors

Charged particle detector systems that would affordably cover large areas with time resolutions in the range below 100 ps and fine segmentation at the cm to sub-mm level have applications for all three Frontiers. Areas of interest are developments that would improve the particle rates of up to MHz/sq.cm, that would reduce cost via use of

commercial batch production and that could provide resolutions ranging down to 10-microns in space and/or 1-psec in time are of interest.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

d. Advanced Composite Materials

The High Luminosity LHC detectors will require ultimate performance detector mechanical support and cooling, that holds detector elements with micron precision and stability, and yet adds as close to zero mass as possible. Developments in this area could also be applicable to other high-priority programs. Of interest are: novel low-mass materials with high thermal conductivity and stiffness, very high thermal conductivity (<4 Wm/K) radiation tolerant adhesives, low mass composite materials with good electrical properties for shielding or data transmission, radiation hard low loss dielectric materials, improvements to manufacturing processes to take advantage of the new materials.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

e. High Purity 6", Single Crystal, Germanium Wafers

High purity Ge, single crystal wafers are necessary for the development and fabrication and development of advanced Ge based charge coupled device (CCD) photon detectors. Proposals to develop a source of 6" wafers, compatible with standard CCD fabrication equipment would be of great interest.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

f. Cryogenic Bolometer Array Technologies

Future Cosmic Microwave Background experiments will require arrays of order 100,000 bolometers. Several fabrication processes are needed to enable such large scale detectors, and can also be applicable to other experiments.

- Sub-kelvin (10-70mK base) cryogenic systems suited for operation of large arrays for superconducting bolometers. New systems would have large operational cryogenic volumes, cryogen-free operation, high cooling power with multiple thermal intercepts, closed-cycle and continuous-cycle operations.
- Mechanical systems and bearings for operation in vacuum at cryogenic temperature.
- Wafer processing combining niobium metal and MEMS.
- Anti-reflective coating technology that allows conformal application with excellent uniformity.
- Production of large area lenslet arrays for IR light, using hard materials, such as sapphire, alumina, and silicon (5mm size 3D features on wafer scale).
- Fabrication of miniature, ultra-low loss, superconducting capacitor and inductor arrays.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

g. Scintillating Materials and Wavelength Shifters

High Energy Physics utilizes scintillating materials for large calorimeters in colliding beam and intensity frontier experiments as well as the active medium in some neutrino and dark matter detectors. Development of radiation-hard, fast scintillators and wavelength shifting materials is of particular interest to the colliding beam community. Development of fast, wavelength-matched shifting materials is of interest for liquid noble gas detectors for neutrinos and dark matter. Brighter, faster, radiation-hard crystals with high density are of interest for intensity frontier experiments as well as colliding beam experiments.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

h. Integral Field Spectrographs for Sky Surveys

The HEP community has identified integral field spectroscopy as an area that could dramatically leverage investments in current and future sky surveys for the study of Dark Energy. Grant applications are sought for the development of instrumentation that would increase the number of spectroscopic channels or the light collection efficiency for future instruments. Examples include, but are not limited to, novel multi-fiber positioning systems, spectrographs, optical filters and sensors.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

i. Technology for Large Cryogenic Detectors

Liquid noble gas detectors are in use and under development for dark matter and neutrino experiments and in the latter case on a very large scale - as large as 10 kton modules of liquid argon for the DUNE experiment. These large scale cryogenic detectors require significant technological advances.

Electrical feedthroughs through cryostat walls are needed for low voltage power, high speed (~1Gb/s) signals, monitoring and control signals, and High Voltage (100 - 200kV) DC bias. A typical case might require 1000 total wires penetrating the cryostat wall, with HV connections having each a dedicated feedthrough. These penetrations need to be area-efficient, minimize cold leaks, and control contamination. Feedthroughs are generally warm (i.e., the interior cable enters the cryostat in the gas rather than liquid phase) but in some instances cold feedthroughs (i.e., entry directly into the liquid) are required.

Purification materials and filtration systems (e.g., submersible low-noise pump) for efficient operation of high purity multi-kiloton cryogenic noble liquid systems are needed.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

j. Ultra-Low Mass, High-Rate Charged Particle Tracking

Some high intensity experiments searching for very rare phenomena, such as neutrino-less coherent muon-to-electron conversion and muon decays to e+e-e- or to e- gamma, require precision charged particle tracking at low momenta in the 10 - 100 MeV/c range. Momentum resolutions of 0.1% are required in order to mitigate steeply falling physics backgrounds, necessitating ultra-low mass designs. Improvements in sensitivity beyond currently planned experiments require the development of technologies capable of achieving the necessary resolutions while operating in vacuum and handling average rates of order10 kHz/cm2 with peak rates approaching 1 Mhz/cm2. The envisioned tracking systems are modestly sized, providing coverage over areas of order 10 m2.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

k. Additive Manufacturing

Detectors for particle physics are often characterized by large areas or large volumes, need exquisite performance and need to be composed of materials that have to withstand harsh conditions, such as ultra-cold, high pressure or high-radiation environments. Additive manufacturing holds the promise to fabricate sensors and detectors that meet the stringent requirements of particle physics experiments in a cost-effective and tailored manner. Proposals are sought in this area that address the specific needs of the experiments.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

l. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Helmut Marsiske, helmut.marsiske@science.doe.gov

REFERENCES:

1. Demarteau, M., et al., 2013, Instrumentation Frontier Snowmass Report, available at http://www.slac.stanford.edu/econf/C1307292/docs/Instrumentation.html

2. Formaggio, J.A. and Martoff, C.J., 2004, Backgrounds to Sensitive Experiments Underground, Annual Review of Nuclear and Particle Science, vol. 54, pp.361-412, available at http://www.annualreviews.org/doi/abs/10.1146/annurev.nucl.54.070103.181248?journalCode=nucl

3. International Workshop on New Photon-Detectors (PHOTODET2012), June 13-15, 2012, Laboratory of Linear Accelerator, Orsay, France, http://photodet2012.lal.in2p3.fr/

4. 8th Trento Workshop on Advanced Silicon Radiation Detectors (3D and P-type) (TREDI2013), February 18-20, 2013, Fondazione Bruno Kessler Research Center, Trento, Italy, http://tredi2013.fbk.eu/

5. Balbuena, J.P., et al., 2012, RD50 status report 2009/2010: Radiation Hard Semiconductor Devices for Very High Luminosity Colliders, Report Numbers: CERN-LHCC-2012-010, LHCC-SR-004, http://cds.cern.ch/record/1455062/files/LHCC-SR-004.pdf

6. Hartmann, F. and Kaminski, J., 2011, Advances in Tracking Detectors, Annual Review of Nuclear and Particle Science, vol. 61, pp. 197-221, Available at http://www.annualreviews.org/doi/abs/10.1146/annurev-nucl-102010-130052

7. Brau, J.E., Jaros, J.A., and Ma, H., 2010, Advances in Calorimetry, Annual Review of Nuclear and Particle Science, vol. 60, pp. 615-644, available at http://www.annualreviews.org/doi/abs/10.1146/annurev.nucl.012809.104449?journalCode=nucl

8. Kleinknecht, K., 1999, Detectors for Particle Radiation (2nd ed.), Cambridge University Press, Cambridge, MA, ISBN 978-0-521-64854-7, available at http://www.gettextbooks.com/author/Konrad_Kleinknecht

9. Knoll, G.F., 2010, Radiation Detection and Measurement (4th ed.), J. Wiley & Sons, Hoboken, NJ, ISBN 978-0-470-13148-0, available at http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP001606.html

10. Spieler, H., 2005, Semiconductor Detector Systems, Oxford University Press, New York, NY, ISBN 978-0-198-52784-8, available at http://www.amazon.com/Semiconductor-Detector-Systems-Science-Technology/dp/0198527845/ref=sr_1_1?ie=UTF8&qid=1412782151&sr=8-1&keywords=9780198527848

11. The Fourteenth International Workshop on Low Temperature Detectors (LTD14), Journal of Low Temperature Physics, August 1-5, 2011, Heidelberg University, Heidelberg, Germany, . ISSN: 1573-7357, vol. 167, available at http://ltd-14.uni-hd.de/

12. The Fifteenth International Workshop on Low Temperature Detectors (LTD15), June 24-28, 2013, California Institute of Technology, Pasadena, CA, http://conference.ipac.caltech.edu/ltd-15/

13. Bartolo, P.J., 2011, Stereolithography: Materials, Processes and Applications, Springer, New York, NY, ISBN 978-0-387-92903-3. Available at http://link.springer.com/book/10.1007%2F978-0-387-92904-0

14. 13th Pisa Meeting on Advanced Detectors, May 24-30, 2015, La Biodola, Isola d'Elba, Italy, http://www.pi.infn.it/pm/2015/

15. International Conference on Technology and Instrumentation in Particle Physics 2014 (TIPP2014), Amsterdam, June 2-6, 2014, The Netherlands, http://www.tipp2014.nl/index.html

16. IEEE Symposium on Radiation Measurements and Applications (SORMA WEST2012). May 14-17, 2012, Oakland, CA, http://sormawest.org/

17. 13th Vienna Conference on Instrumentation, February 11-15, 2013, Vienna, Austria, http://vci.hephy.at

PROGRAM AREA OVERVIEW – OFFICE OF NUCLEAR ENERGY

The primary mission of the Office of Nuclear Energy (NE) is to advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs by resolving technical, cost, safety, proliferation resistance, and security barriers through research, development, and demonstration as appropriate.

Continued use of nuclear power is an important part of the Department's strategy to provide for the Nation's energy security, as well as to be responsible stewards of the environment. Nuclear energy currently provides approximately 20 percent of the U.S. electricity generation and will continue to provide a significant portion of U.S. electrical energy production for many years to come. Also, nuclear power in the U.S. makes a significant contribution to lowering the emission of gases associated with global climate change and air pollution.

The Office of Nuclear Energy's SBIR/STTR workscopes also support the DOE Gateway for Accelerated Innovation in Nuclear (GAIN) initiative (see https://gain.inl.gov) that was announced by the White House in November 2015, which provides the nuclear energy community with access to the technical, regulatory, and financial support necessary to move new or advanced nuclear reactor designs toward commercialization while ensuring the continued safe, reliable, and economic operation of the existing nuclear fleet.

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

29. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

New methods and technologies are needed to address key challenges affecting the future deployment of nuclear energy and to preserve U.S. leadership in nuclear science and engineering, while reducing the risk of nuclear proliferation. This topic addresses several key areas that support the development of crosscutting and specific reactor and fuel cycle technologies.

Grant applications are sought in the following subtopics:

a. Advanced Sensors and Instrumentation (Crosscutting Research)

Improvements and advances are needed in the technical area of Advanced Sensors and Instrumentation for crosscutting technologies for innovative sensors and measurement technologies to characterize parameters that directly support existing power reactors, materials test reactors, and transient test reactors; enable the development of advanced

power reactor designs; and facilitate development and implementation of advanced fuel cycle technologies. The selected technology should support the Gateway for Accelerated Innovation in Nuclear (GAIN) Initiative and be applicable to multiple reactors or fuel cycle applications, i.e. crosscutting.

Applications are sought in the following areas:

1. Sensors using advanced manufacturing techniques that can be qualified and applied to process measurements needed for nuclear energy systems and their anticipated service environments. Of high interest are multimodal sensors/sensor networks capable of simultaneous measuring more than one parameter and sensors/sensor networks incorporating inherent common cause failure resistance by measuring parameters via more than one physical signal.
2. Digital monitoring and control systems that increase nuclear plant system reliability, availability, and resilience including the ability to detect and manage faults in I&C systems and plant components;
3. Nuclear Plant Communication technologies that securely and reliably support greater data generation and transmission demands expected to accompany advancements in digital sensor, measurement, and control technologies. This may include power harvesting, energy storage, data transmission techniques, and related methods to reduce both power cabling and communication cabling needed for sensors and communications in I&C systems.
4. Development of technologies to enable use of advanced instrumentation for severe environments (including the high temperature, high pressure, high radiation environment expected for transient testing). This could include technologies for compact form factor, leak-tight fiber optic pressure-vessel feed-through systems for multiple fiber sealing and/or development of small form factor, wide field-of-view, high frame-rate, high-resolution, infrared/optical boroscope or other video probe technologies.

Grant applications that address the following areas are NOT of interest for this subtopic and will be declined: nuclear power plant security, homeland defense or security, or reactor building/containment enhancements; radiation health physics dosimeters (e.g., neutron or gamma detectors), and radiation/contamination monitoring devices; U. S. Nuclear Regulatory Commission probabilistic risk assessments or reactor safety experiments, testing, licensing, and site permit issues.

Questions - contact Suibel Schuppner, Suibel.Schuppner@nuclear.energy.gov

b. Advanced Technologies for the Fabrication, Characterization of Nuclear Reactor Fuel

Improvements and advances are needed for the fabrication, characterization, and examination of nuclear reactor fuel. Advanced technologies are desired for light water reactor fuels and materials and for advanced reactor fuels including particulate based TRISO

fuels for Advanced Gas-Cooled Reactors/NGNP applications [2, 3, 5, 6] and fuels for sodium and lead fast reactors. Specific technologies that improve the safety, reliability, and performance in normal operation as well as in accident conditions are desired.

1. Provide new innovative LWR fuel concepts, to include fuel and/or cladding, with a focus on improved performance (especially under accident scenarios), develop radiation-tolerant electronics for characterization instrumentation for use in hot cell fuel/cladding property measurements or characterization. Improvements to LWR fuel and cladding may include but not be limited to fabrication techniques or characterization techniques to improve the overall performance or understanding of performance of the nuclear fuel system.

2. Develop advanced automated, accurate, continuous vs. batch mode process techniques to improve TRISO particle fuel and compacts to include: (a) improved fabrication methods for TRISO fuel kernels, particle coatings, pebbles and compacts, automated fabrication and characterization methods to replace manual manufacturing techniques, and (b) advanced methods for non-destructive evaluation testing of TRISO particles and compacts for demonstration.

3. Develop improved fabrication methods for sodium fast reactor fuels and cladding materials, especially for uranium based metallic fuel.

Grant applications may use non-fueled surrogate materials to simulate uranium, plutonium, and minor actinide bearing fuel pellets or TRISO particles for demonstration. Actual nuclear fuel fabrication and handling applications which require use of the Nuclear Science User Facilities [4], and its hot cells and fuel fabrication laboratories, or the Oak Ridge National Laboratory Advanced Gas Reactor TRISO fuels laboratory facilities [5, 6] to demonstrate the techniques and equipment developed may be proposed. Actual nuclear fuel specimens may be considered for ATR or ORNL High Flux Isotope Reactor (HFIR) but will need to prove technical feasibility prior to their insertion into the ATR or HFIR for irradiation testing. Access to the aforementioned facilities is not guaranteed as part of this solicitation and must be obtained independent of an SBIR/STTR award.

Grant applications that address the following areas are NOT of interest and will be declined: thorium based fuels, spent fuel separations technologies used in the Fuel Cycle Research and Development Program [3] and applications that seek to develop new glove boxes or sealed enclosure designs.

Questions - contact Frank Goldner, Frank.Goldner@nuclear.energy.gov

c. Energy Innovation Modeling and Simulation Hub / Consortium for Advanced Simulation of Light Water Reactors (CASL)

High-fidelity computational simulations are beginning to provide predictive analysis capabilities for the design and performance assessment of nuclear reactor components and fuel assemblies. The multiphysics and multiscale integration needed to achieve these capabilities also generates a growing dependence on high performance computing architecture, which can present some usability challenges. To address these challenges, we are seeking grant applications for software development to enhance the usability of advanced multiphysics computational tools, and encourage their broader commercial deployment. Desired software development includes, but is not limited to:

- Development of Python based Graphical User Interface (GUI) which can visualize reactor geometry, code discretizations, parallel domain decompositions and multi-cycle fuel element shuffling maps required for core burnup and fuel cycle calculations. The GUI should be compatible with unified multi-physics input structures such as the VERAin structure used by the CASL program.
- Development of visualization tools that address specific challenges in nuclear reactor performance and safety analysis. Such tools may be embedded in the analysis code or called as a library to facilitate embedded visualization in large parallel computing jobs specific challenges of interest include:
    - Capability to visualize 2d-1d MOC method transport code geometry and discretization for up to full-core pin-by-pin simulations.
    - Capability to visualize common integrated input geometry and discretization specification (such as VERAin) and compare with representation implemented in constituent analysis codes (such as MPACT, COBRA-TF or BISON in CASL's VERA suite).

Questions - contact Tansel Selekler, Tansel.Selekler@nuclear.energy.gov

d. Modeling and Simulation

Computational modeling of nuclear reactors is critical for their design and operation. Nuclear engineering simulations are increasingly predictive and able to leverage high-performance computing architectures, but these advanced tools often require large computational resources, can be difficult to install, and require expert knowledge to operate. It is desirable to integrate robust multiphysics capabilities and current production tools to provide ease-of-use and deployment to end users, enabling the use of high-fidelity simulations to inform lower-order models for the design, analysis, and licensing of advanced nuclear systems and experiments.

Grant applications are sought that:

- Facilitate access to advanced modeling and simulation tools for inexperienced users, such as automated generation of finite element meshes, especially hexahedra meshes, from CAD or combinatorial solid geometry models;
- Facilitate workflow management between legacy physics software commonly used in nuclear engineering practice and modern high-fidelity codes that are more predictive but incur a higher computational cost. It is desirable to integrate consistent workflows where a user can select physics modules of differing fidelity and have a workflow manager transfer data from one tool to the next, enabling a user to choose among multiple high- or low-fidelity tools for each type of physics in a multiphysics simulation.
- Apply the results of high-fidelity simulations to inform the improved use of lower-order models for improved use of fast-running design tools; and
- Provide capabilities for automated verification of numerical solutions, including mesh refinement studies.

Questions - contact Dan Funk, Dan.Funk@nuclear.energy.gov

e. Non-Destructive Examination (NDE) of Materials Used in Nuclear Power Plants

Selective leaching or de-alloying, the preferential removal of one element from an alloy, is a problem that can occur in gray cast iron, as well as in copper alloys with concentrations greater than 15% zinc or 8% aluminum. Traditional NDE technologies may address changes in pipe wall thickness, which may provide little information on the effect that leaching has on the mechanical properties and stability of the pipe. For example, selective leaching in gray cast iron involves the preferential removal of iron from the alloy resulting in a significantly weakened pipe without changes in pipe wall thickness. Proposals are sought that develop new and innovative ideas to provide field deployable non-destructive testing techniques or monitoring technologies for the evaluation of buried and underground piping capable of evaluating corrosion processes such as leaching.

Questions - contact Richard Reister, Richard.Reister@nuclear.energy.gov

f. Component Development for Energy Conversion Systems to Support Nuclear Power Systems

The Department of Energy (DOE) sponsorship, has made substantial contributions over the last decade to the development of Brayton power cycles. Brayton power cycles provide industry value through increased efficiency and a smaller overall system footprint compared to industry standard steam-based power conversion cycles.

DOE seeks to engage with small business vendors on development of key system components in an effort to retire technical risks for fast track commercial system deployment, to address technology challenges and collaborative opportunities for sCO_2 and other types of Brayton power cycles development for converting thermal energy.

Opportunity Description:
DOE is seeking proposals for collaborative small business partnerships from a U.S. company or companies to advance both the sCO_2 and other types of Brayton power cycle systems and foster growth for U.S. industry. Potential areas of collaboration include but are not limited to:

- High temperature Seals and Bearings
- Ceramic based Bearing/Seal technology
- Advancement of Pressure Activated Leaf Seals (PALS)
- Thermal management of SCO_2 turbomachinery
- Strengthened materials to prevent erosion in Turbomachinery
- Turbomachinery development for 900C operation
- Advanced cooling techniques for low temperature sCO_2 bearings and seals being implemented in high temperature systems
- Thermal tuning of sCO_2 turbine inlet conditions
- Advanced filtration in sCO_2 with low pressure drop filters
- Piping systems to accommodate 900C conditions
- Waste heat recovery using sCO_2 Brayton cycles with diesel gen sets
- Hermetically Sealed Torque Couplers
- Electro-Dynamic Magnetic Bearings
- Additive Manufacturing of turbines and compressors
- Fast response throttle, bypass, and stop valves
- Ceramic PCHEs
- Cast material heat exchangers
- Fast Response Magnetic bearings
- Dry heat rejection

Questions - contact Brian K. Robinson, Brian.Robinson@nuclear.energy.gov

g. Advanced Methods for Manufacturing

A strong manufacturing base is essential to the success of U.S. reactor designs currently competing in global markets, but the success of the Small Modular Reactor (SMR) Initiative depends heavily on the ability of the U.S. to deliver on the SMR's expected advantages – the capability to manufacture them in a factory setting, dramatically reducing the need for costly on-site construction – thereby enabling these smaller designs to be economically competitive. This workscope also supports the Department of Energy's Gateway for Accelerated Innovation in Nuclear (GAIN) initiative. In addition to Light Water and Advanced SMRs and ALWRs, recent technology specific workshops that were organized by GAIN, in coordination with Electric Power Research Institute (EPRI) and Nuclear Energy Institute (NEI), identified specific needs in Molten Salt, High Temperature Gas, and Fast Reactor technologies.

One area is appropriate for development by small businesses.

Advanced fabrication and manufacturing methods will require advances in welding processes and inspection methods that can maintain production speed and efficiency with the manufacturing processes. Component manufacturing technologies will be required that take full advantage of the new 3-D printing methods employed by Additive manufacturing technologies. These manufacturing methods must be capable of producing components or sub components on a limited production basis and with nuclear quality. Grant applications are sought for (1) methods to improve the process, speed, quality and cost of welding and the required in-process and post welding inspections and (2) methods and processes to fabricate components using advanced technologies like 3D printing forms of Additive manufacturing processes that can eventually produce nuclear quality components. Grant applications are also sought for methods that can improve the manufacturing processes required for nuclear components using "Just in time" manufacturing methods adapted from other industries.

Questions - contact Alison Hahn, Alison.Hahn@nuclear.energy.gov

h. Material Recovery and Waste Forms for Advanced Domestic Fuel Cycles

Material recovery and waste forms play critical roles in both current and future nuclear fuel cycles. Currently, research reactor fuels are being processed in the U.S. for their stabilization while large nuclear waste treatment processing plants are in operation and are being constructed to convert cold war liquid waste into safely storable solid waste forms. An additional plant is being built to convert weapons-grade plutonium into commercial nuclear fuel. In the future, chemical processing plants may be constructed in the U.S. to recycle used nuclear fuel for improved resource utilization and reduced environmental impact. In all cases, modest improvements in chemical processing technologies can effect significant cost reductions.

In addition to the use of advanced sensors and measurement technologies for materials protection, accounting and control (as outlined in subtopic c), grants are sought for the development of related systems useful for material recovery process control. For example, detectors that may indicate unauthorized materials diversion can be equally useful in identifying system upsets and the need for control changes. Grant applications are sought for the development of dual-use as well as single purpose instruments and detectors used exclusively for process control. However, proposals that are focused on materials protection, accounting and control related applications are more appropriate for subtopic c and should be submitted there.

Most liquid high-level nuclear waste in the world is being converted to a solid form as a borosilicate glass. Such waste forms, while extremely durable, generally contain low concentrations of radioactive materials. Several approaches are under investigation to increase radioactivity concentrations and thus to decrease the total waste mass and volume

for storage and disposal. Examples include the possible use of metal alloys and ceramics as advanced waste forms. Innovations are needed in waste forms chemistry and crystallinity to increase waste concentrations without the sacrifice of glass durability. Acceptability of such new waste forms as alternatives to borosilicate glass will depend upon sufficient knowledge of their degradation processes to be able to predict their performance over geologic time periods. Collaboration with national laboratory scientists involved in related studies is encouraged.

Questions - contact James Bresee, James.Bresee@nuclear.energy.gov

i. Cybersecurity Technologies for Protection of Nuclear Safety, Security, or Emergency Response Components and Systems

The U.S. Department of Energy Office of Nuclear Energy is seeking science and engineering solutions that provide nuclear operators with tools to implement intelligent and cybersecure digital systems that enable nuclear energy to continue to be a viable option in meeting electrical power demands. To establish a science-based foundation that assures the secure operations of these digital systems, proposals of interest should address innovative technologies or methodologies that support fundamental digital system architectural features that include cybersecurity within the design and/or establish the foundation for cybersecure control system architecture design requirements and standards.

Questions - contact Trevor Cook, Trevor.Cook@nuclear.energy.gov

j. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Won Yoon, Won.Yoon@nuclear.energy.gov

REFERENCES: Subtopic a-l:

1. United States Department of Energy Office of Nuclear Energy, Home Page. http://energy.gov/ne/office-nuclear-energy

2. Nuclear Energy Research and Development Roadmap, Report to Congress. United States Department of Energy Office of Nuclear Energy. April 2010. http://energy.gov/ne/downloads/nuclear-energy-research-and-development-roadmap

3. United States Department of Energy. Fuel Cycle Research and Development Program. http://energy.gov/ne/nuclear-reactor-technologies/fuel-cycle-technologies

4. Technical Program Plan for the Next Generation Nuclear Plant/Advanced Gas Reactor Fuel Development and Qualification Program. Idaho National Laboratory. Rev. 3, INL/EXT-05-00465. August 2010. Available at

https://inlportal.inl.gov/portal/server.pt/community/ngnp_public_documents/452/home

5. D. Petti, et al. (2005). The DOE Advanced Gas Reactor (AGR) Fuel Development and Qualification Program. 2005 International Congress on Advances in Nuclear Power Plants INEEL/CON-04-02416. http://www.inl.gov/technicalpublications/Documents/3169816.pdf

REFERENCES: Subtopic g:

1. V. Dostal, M.J. Driscoll & P. Hejzlar. (2004). A Supercritical Carbon Dioxide Cycle for Next Generation Nuclear Reactors. Advanced Nuclear Power Technology Program. Report MIT-ANP-TR-100. http://web.mit.edu/course/22/22.33/www/dostal.pdf

2. J.J. Sienicki, et al. (2011). Scale Dependencies of Supercritical Carbon Dioxide Brayton Cycle Technologies and the Optimal Size for a Next-Step Supercritical CO_2 Cycle. Supercritical SCO_2 Power Cycle Symposium. May 24-25, 2011, Boulder, CO. Available at http://www.sco2powercyclesymposium.org/resource_center/development_priorities/scale-dependencies-of-supercritical-carbon-dioxide-brayton-cycle-technologies-and-the-optimal-size-for-a-next-step-supercritical-co2-cycle-demonstration

30. ADVANCED TECHNOLOGIES FOR NUCLEAR WASTE

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The US DOE office of Nuclear Energy, Office of Used Nuclear Fuel Disposition (UNFD) R&D is currently conducting research in long-term storage, transportation and disposal of used nuclear fuel (UNF). Storage of UNF is occurring for longer periods than perhaps first intended, therefore it is desirable to address technical performance issues of the nuclear containing materials with time. Improvements and advances for the development, design, and testing of new sensors, transmitters, and measurement techniques for UNF stored in dry storage systems for long periods of time could be beneficial. In the area of disposal, research is directed toward generic repository disposal systems in crystalline/granite, shale, salt and deep borehole environments.

Grant applications are sought only in the following subtopics:

a. New Technology for Monitoring the Conditions of Used Nuclear Fuel inside Dry-Storage Canisters

Grant applications are sought for developing new technologies for monitoring the condition of used nuclear fuel inside dry-storage canisters. Various components of the monitoring system might be located inside the canister or externally, depending on the proposed approach. If some of the components are to be located inside the canister, they would have to sustain harsh environments (including high radiation, high temperatures, and vibration) for long periods of time (centuries) without accessibility for maintenance or calibration. They would also have to sustain reorientation and vibration associated with

loading and shipping the canisters from the reactors to the storage facilities. If located inside the canister, there could be no penetrations through the canister; they would have to be powered without direct connections and the signals would have to be transmitted without direct connection (through thick steel shells and, possibly, concrete over-packs). The monitoring system might include the following components:

1. Sensors: Develop sensors to monitor the condition of used nuclear fuel inside dry-storage canisters, specifically, to identify or predict fuel cladding failure and fuel assembly structural degradation/corrosion [1, 2, 3, 4]. The attributes to be monitored might include radiation levels, temperatures, pressures, detection of certain gasses including corrosion products and radioactive decay elements, etc.
2. Transmitters: Develop transmitters (and receivers) for the signal from the sensors inside the used nuclear fuel dry-storage canister to the outside receivers.
3. Power supply: Develop autonomous power supply devices for the sensors and/or transmitters, if they are to be located inside the canister.

Questions - contact John Orchard, John.Orchard@doe.gov

b. Canister Repair and Mitigation Techniques

While long-term material performance studies are planned within the Used Nuclear Fuel Disposition (UNFD) program, there are limited opportunities to perform reliable real-time monitoring of the material condition in a sealed container or a dry storage cask. There are several monitoring devices that can be used for conventional non-destructive examinations. However, the current monitoring devices only provide limited information and the long-term reliability of the data could be questionable. Of interest to the UNFD program are grant applications that propose new devices based on long-term material behavior characteristics and/or propose new data collection and advance analyses methods that can support reliability of long-term storage options. While this active research that addresses detection and sizing of flaws, there needs to be a focused research activity associated with the repair and mitigation of flaws once they are detected on a canister surface. The focus of this new research, therefore, is to develop in-situ repair mechanisms for canister flaws that can be conducted with the canister fully loaded, thermally hot, and highly radioactive. The successful repair would provide regulatory justification that the repaired canister can remain in service or be returned to service and successfully perform its confinement function. Technical issues to be addressed include;

- working in confined spaces,
- working in thermally hot conditions
- working on potentially non-uniform surfaces, such as adjacent to weld beads
- highly radioactive conditions requiring radiation-hardened equipment
- operational dose (ALARA) concerns
- potential for remote operations
- verification of the repair

- evaluating and mitigating the potential effects of surface contamination (dirt, corrosion product, etc.) that might interfere with the repair process or with verification of the repair

Associated with this research is mitigation of a loss-of-confinement flaw that may not be fully repaired, but can still be justified as providing the confinement function. Examples of this include the possibility that it may not be feasible to fully repair a deep flaw (e.g., flaw orientation or location in the canister). Mitigations techniques may provide an alternative solution to fully repairing a deep flaw using conventional methods.

It is recognized that some areas of the canister surface—for instance, adjacent to, or in contact with, support or alignment rails—will not be accessible to in situ repair. Therefore, proposed ex situ methods such as repair and inspection "rings," used in conjunction with transfer casks, will also be given consideration.

Questions - contact Prasad Nair, Prasad.Nair@doe.gov

c. Used Fuel Disposition Geologic Mined Repository in Clay, Salt, Crystalline Rock and Borehole (Casing Cement, Plugs, Sealing, and Sealing Defect Prevention, Detection, Improvements)

New methods and technologies could address key issues that affect the materials disposition associated with the back-end of the nuclear fuel cycle specifically the dispositioning of defense program high-level nuclear waste products and used nuclear fuel from civilian reactors. The UNFD program is currently investigating generic repository disposal systems in crystalline/granite, shale, salt, and deep borehole environments.

Science, engineering, and technology improvements may advance our understanding of generic deep geologic environments (e.g., salt, clay, granite geologic repository and boreholes drilled to 5 km depth into "crystalline basement" rock) and will facilitate the characterization of the natural system and better enable analysis of expected natural system performance during the post-closure period. Research and development challenges exist that require the DOE to provide reasonable assurance that the disposal system isolates the waste for an extended time period (i.e., engineered and natural systems work together to prevent or delay migration of waste components to the accessible environment). Demonstration of isolation generates business opportunities supportive of the UFD mined repository and ongoing generic disposal system investigations. Thus, the DOE invites proposals for borehole seal development and seal integrity demonstration (e.g., casing cement, plug). Borehole seal and cement technologies should promote isolation of waste forms in the natural system disposal zone from encasing rock units and from shallower water bearing zones.

Questions - contact Mark Tynan, Mark.Tynan@doe.gov

d. Groundwater Residence Time for Very Old Formation Waters

Proposals are sought to evaluate, improve, and or optimize the reliability, accuracy, and/or performance of instrumentation, sampling and testing methods and applications, and the modeling analysis of isotopic composition of formation pore and fracture water for age determination, in particular for residence time determination of very old groundwater with an age range in the millions to billions of years. Proposals are sought regarding methods advancing groundwater age dating and reliability of estimated groundwater residence time for very old groundwater. Proposals may address sampling method improvements, test specifications, materials, hardware requirements, test methods, distinguishing age of pore waters and fracture waters or determination of hydrologic system character and formation water residence time.

Questions - contact Bill Spezialetti, william.spezialetti@doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Joe Price, joe.price@doe.gov

REFERENCES: Subtopic a-b:

1. Licensing Requirements for The Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor- Related Greater than Class C Waste, General Design Criteria, Overall Requirements. 10 CFR 72.122. Available at http://www.nrc.gov/reading-rm/doc-collections/cfr/part072/

2. Licensing Requirements for The Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor- Related Greater than Class C Waste, General Design Criteria. 10 CFR 72.128. Criteria for spent fuel, high-level radioactive waste, and other radioactive waste storage and handling. Available at http://www.nrc.gov/reading-rm/doc-collections/cfr/part072/part072-0128.html

3. Gap Analysis to Support Extended Storage of Used Nuclear Fuel Rev. 0. United States Department of Energy, FCRD-USED-2011-000136, Rev. 0. Used Fuel Disposition Campaign. January 31, 2012. Section 4.6 Monitoring. http://www.energy.gov/sites/prod/files/Gap%20Analysis%20Rev%200%20Final.pdf

REFERENCES: Subtopic c:

1. Nuclear Energy Research and Development Roadmap, Report to Congress. April 2010. United States Department of Energy Office of Nuclear Energy. http://nuclear.energy.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf

2. P. Brady, et al. Deep Borehole Disposal of High-Level Radioactive Waste. Sandia National Laboratories. Albuquerque, NM. SAND2009-4401. http://prod.sandia.gov/techlib/access-control.cgi/2009/094401.pdf

3. Nuclear Energy Research and Development Roadmap: Report to Congress. April 2010. http://www.ne.doe.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf

4. F.E. Dozier, et al. Feasibility of Very Deep Borehole Disposal of US Nuclear Defense Wastes. MIT-NFC-TR-127, Nuclear Fuel Cycle Program. Massachusetts Institute of Technology Center for Advanced Nuclear Energy Systems. Cambridge, Massachusetts. Available at https://canes.mit.edu/publications/feasibility-very-deep-borehole-disposal-us-nuclear-defense-wastes

5. G. Heiken, et al. (1996). Disposition of Excess Plutonium in Deep Boreholes, Site Selection Handbook. Los Alamos National Laboratory. LA-13168-MS (UC-721). http://library.lanl.gov/cgi-bin/getfile?00406632.pdf

6. "A Review of the Deep Borehole Disposal Concept for Radioactive Waste." United Kingdom Nirex Ltd., (Nirex currently is UK Nuclear Decommissioning Authority [NDA], Radioactive Waste Management Directorate June 2004. http://www.mkg.se/uploads/Nirex_Report_N_108_-_A_Review_of_the_Deep_Borehole_Disposal_Concept_for_Radioactive_Waste_June_2004.pdf

REFERENCES: Subtopic d:

1. L. Lin, et al. (2005). The Yield and Isotopic Composition of Radiolytic H2, a Potential Energy Source for the Deep Subsurface Biosphere. Geochimica et Cosmochimica Acta. Volume 69. Number 4. pp. 893–903. Available at http://www.sciencedirect.com/science/article/pii/S0016703704006271

2. J. Lippmann, et al. (2003). Dating Ultra-deep Mine Waters with Noble Gases and 36Cl, Witwatersrand Basin, South Africa. Geochimica et Cosmochimica Acta. Volume 67, Issue 23. pp. 4597-4619. Available at http://www.researchgate.net/publication/222664676_Dating_ultra-deep_mine_waters_with_noble_gases_and_36Cl_Witwatersrand_Basin_South_Africa

3. F. Phillips, et al. Groundwater Dating and Residence Time Measurements. Treatise on Geochemistry. Volume 5. pp. 451- 497. http://www.ees.nmt.edu/outside/courses/hyd558/downloads/Set_8a_IntroDating/GWDating_ResTime.pdf

4. J. Lippmann-Pipke, et al. (2011). Neon Identifies Two Billion Year Old Fluid Component in Kaapvaal Craton. Chemical Geology. Volume 283. pp. 287–296. http://www.princeton.edu

31. NUCLEAR SCIENCE USER FACILITIES

Maximum Phase I Award Amount: $150,000	**Maximum Phase II Award Amount:** $1,000,000
Accepting SBIR Phase I Applications: YES	**Accepting STTR Phase I Applications:** YES

The Nuclear Science User Facilities (NSUF) is one of a diverse number of U.S. Department of Energy (DOE) user facilities established to provide researchers with the most advanced tools of modern science. NSUF is the DOE Office of Nuclear Energy's (DOE-NE) first and only sponsored user facility, and is singularly focused on advancing technologies supporting nuclear energy applications. The NSUF is fairly unique in that it is not formed from a single self-contained facility but represents a consortium of facilities distributed across the U.S. at a number of institutions. The NSUF is centered at and managed from the Idaho National Laboratory (INL), where it was originally founded. NSUF partner facilities include eight universities, plus the three Idaho universities that are part of the Center for Advanced Energy Studies (CAES), four national laboratory facilities, and one industry facility. Inclusion of additional partner facilities as well as international affiliations is anticipated in the future.

The NSUF goal is to produce the highest quality research results that will increase understanding of advanced nuclear energy technologies important to DOE-NE and support national priorities by adapting to the needs of DOE-NE programs, industry, and new innovative concepts. The core mission of the NSUF is to provide the nuclear energy researchers with no-cost access to its specialized and often unique R&D capabilities. Through this process, the NSUF program fosters the development of novel ideas provided by external contributors from universities, national laboratories, and industry while promoting collaborations between those contributors and the expertise associated with the NSUF partner capabilities. These collaborations define the cutting edge of nuclear technology research in high temperature and radiation environments, contribute to improved industry performance of current and future nuclear reactor systems, and stimulate cooperative research between user groups conducting basic and applied research.

Grant applications are sought in the following subtopics:

a. Development of Advanced Concepts for Remote Mechanical Testing of Highly Irradiated Materials

Grant applications are sought to adapt existing or develop novel mechanical testing capabilities for use in a high-radiation environment in a hot cell. The equipment would have to be able to withstand a high-radiation environment as well as be remotely operated in all stages of the test as well as system installation, calibration, cleaning and repair.
Particular interest is in the ability to test small sample sizes (sub ASTM E8).
The primary location for this capability is the Hot Fuel Examination Facility (HFEF) at the Idaho National Laboratory (INL). HFEF is one of the largest hot cells dedicated to radioactive materials research at INL. The nation's lead laboratory for nuclear energy research and development utilizes HFEF capabilities for remote handing of highly irradiated materials to support research and development of safer and more efficient fuel designs and to evaluate

material performance after irradiation. HFEF has two large, highly shielded hot cells with handling and loading facilities capable of receiving large shipping casks and fuel assemblies up to 12 feet long. The main cell, which is stainless steel-lined and gas tight, has 15 workstations, each with a 4-foot thick window of oil-filled, cerium-stabilized glass and a pair of remote manipulators.

Questions - contact Alison Hahn, Alison.Hahn@nuclear.energy.gov

b. Development of Resistance Welding Capability

Grant applications are sought to develop advanced joining capability in the area of resistance welding. Resistance welding is a thermo-electric process in which heat is generated at the interface of the parts to be joined by passing an electrical current through the parts for a precisely controlled time and under a controlled pressure (also called force). To leverage NSUF's investments, we are seeking to add a resistance welding system to our capabilities.

As the nation's lead nuclear energy laboratory, Idaho National Laboratory is committed to a) accelerating innovation in nuclear energy manufacturing (part of the GAIN initiative – Gateway for Accelerating Innovation in Nuclear) and b) deploying the world's first SMR in Idaho. INL is partnered with several companies, including NuScale, TerraPower, GE, Premier Technologies, and others) to achieve this objective. INL is building capabilities for advanced joining technologies that support these corporate partners who are investing in this area.

Questions - contact Alison Hahn, Alison.Hahn@nuclear.energy.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Alison Hahn, Alison.Hahn@nuclear.energy.gov

REFERENCES:

1. Nuclear Science User Facilities, Home Page. https://nsuf.inl.gov/