Topic 1: Advanced Building Air Conditioning and Refrigeration, Thermal Load Shifting, and Cool Roofs

The Department of Energy is seeking the development of advanced technologies for:

(1) air conditioning and refrigeration in buildings that are more energy efficient than today's technologies and that avoid net direct greenhouse gas emissions from the working fluids;
(2) thermal load shifting of cooling (or heating) loads;
(3) reducing thermal loads on roofs and that increase albedo to provide a "cool roof" effect, including tunable roofing elements for both cooling in summer and heating in winter.

Grant applications submitted in response to this topic should: (1) include a review of the state-of-the-art of the technology and application being targeted; (2) provide a detailed evaluation of the proposed technology and place it in the context of the current state-of-the-art; (3) analyze the proposed technology development process, the pathway to commercialization, and the attendant potential public benefits that would accrue; (4) address the ease of implementation of the new technology, its ability to be installed with commonly-available skill sets, and its potential for high reliability; (5) demonstrate that the proposed technology has the potential to be more energy efficient and have reduced lifecycle costs compared to current technologies; (6) have high reliability; and (7) address a large potential market.

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

Grant applications are sought in the following subtopics:

a. **Air Conditioning and Refrigeration in Buildings—**Refrigeration and air conditioning in buildings accounts for approximately 8.5 quads of U.S. primary energy consumption. Most conventional air conditioners, heat pumps, and refrigerators achieve cooling through a mechanical vapor compression cycle (VCC). Unfortunately, there does not appear to be any economically viable path to dramatic improvements in the efficiency of today's VCC systems; such improvements, where possible, would significantly increase the price of the equipment. Further, air conditioning is a major contributor to electric utility peak loads, which incur high generation costs and generally use inefficient and polluting generation turbines. Peak loads are also a major factor in poor grid reliability. A related problem with today's VCC cooling technology is the adverse environmental impact of the refrigerant gases used. Although the hydrofluorocarbon (HFC) refrigerants used today are relatively safe for the ozone layer, they are strong greenhouse gases. A recent study projected that in 2050, if CO_2 is stabilized at 450 ppm, HFCs would increase radiant greenhouse gas forcing by 28-45 percent (Velders).

These factors necessitate a search for new approaches to increase the energy efficiency of cooling technologies. Technologies of interest include: (1) solid-state materials and devices; (2) advanced working fluids and their corresponding mechanical vapor compressions systems; and

(3) advanced absorption cycles, particularly those that use waste heat or solar energy.

(1) For solid-state materials and devices, the technology must provide higher energy efficiencies than current VCC technologies and provide highly-durable long-life units at comparable or reduced costs compared to today's conventional technologies. Therefore, grant applications are sought to develop solid state materials and technologies that have the potential to provide improved cost and performance compared to conventional VCC technologies. Areas of interest include solid-state materials and devices such as magnetocalorics, electrocalorics, thermotunneling, or other solid state systems. Thermoelectrics will not be considered in this solicitation and will be the focus of a separate SBIR solicitation Topic in September of this year.

(2) For advanced working fluids and mechanical VCC systems, the technology must provide higher energy efficiencies than current VCC technologies, eliminate fluorocarbon refrigerants and direct net greenhouse gas impacts, and provide highly-durable long-life units at comparable or lower costs than today's conventional technologies. Therefore, grant applications are sought to develop novel working fluids without a net direct greenhouse gas impact and the mechanical VCC systems that are suitable for these new refrigerants.

(3) Advanced absorption cycles offer the opportunity to use waste heat or solar energy. Current systems have low efficiency and generally require a high temperature to regenerate the refrigerant. These temperatures are typically too high for simple flat plate solar collectors, thus necessitating more expensive and complex systems. Therefore, grant applications are sought to develop novel absorption cycles that can operate at low temperatures with solar energy or waste heat, thus enabling lower capital costs.

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

b. **Thermal Load Shifting—**Another approach to the problem of high utility peak loading due to air conditioning, noted above, is the development of innovative technologies to control peak loads through shifting thermal loads to other times of the day. Such technologies may also play a role in enabling greater market penetration of variable renewable energy technologies such as wind, by shifting the cooling load to nighttime, when wind resources are more readily available.

Thermal load shifting can be provided by either passive storage, such as thermal mass in the building envelope, or active systems, through thermal storage of energy via chilled water or ice storage. However, because buildings operate in a dynamic environment that has an important influence on energy performance, mismatches may arise between this environment and the thermal-load-shifting solution. These mismatches can lead to poor design choices and limit the ability to properly assess some of the most promising technologies. Some of these issues have been identified as requiring further research and development, and are described in the DOE Building Technologies multi-year program plan (http://www1.eere.energy.gov/buildings/mypp.html). Under this subtopic, these and other technology opportunities are sought that might have a positive and lasting impact on peak reduction and energy efficiency in buildings by thermal load shifting. In particular, grant applications are sought in the following areas, to develop:

- phase-change energy storage within light-weight building systems.
- active thermal storage systems, which have been shown to reduce peak demand, but with an energy use penalty.
- building envelope systems that harvest both the thermal and electrical energy generated by renewable technologies.
- highly conductive composites to boost the performance of thermal storage products and energy distribution systems.
- envelope systems that actively maintain a selected temperature at a location within the wall's core, in order to minimize net heat losses and gains

DOE is interested in research and development in advanced systems that provide peak reduction while also minimizing the energy use penalty.

Questions - contact Marc LaFrance, 202-586-9142, Marc.Lafrance@ee.doe.gov

c. **Advanced Materials for Roofing that Provide High IR Reflectivity and Are Architecturally Acceptable, Including Cool Roofs—** Building roofs are often high absorbers of solar radiation, increasing the cooling load on buildings and the overall absorption of solar radiation by the earth. Simply coating the roof with a highly reflecting paint or coating can potentially reduce this thermal load. In large numbers, such high reflectivity roof coatings could also provide a small geoengineering effect by reducing absorption of solar radiation and thereby offsetting greenhouse warming somewhat. Many of these issues and needs have been identified for research and development, and are described in the DOE Building Technologies multi-year program plan (http://www1.eere.energy.gov/buildings/mypp.html). Grant applications are sought to develop low-cost fundamental new material systems that can reduce heat flow into the building and reflect solar energy, provide long lifetime performance, are conducive to control, and are aesthetically and architecturally attractive. Approaches of interest should have a positive and lasting impact on energy efficiency in buildings and should increase the albedo of building roofs to provide a "cool roof" effect. In particular, grant applications are sought in the following areas:

- For roofing systems, the development of durable, affordable and aesthetically attractive tunable materials are of particular interest.
- The development of adjustable emissivity surfaces would enable control of heat flow seasonally and diurnally.
- The development of highly reflective roofing surfaces that have less than five percent three-year-aged-value degradation are also of interest. Innovative coating processes to address the high cost of coating asphalt shingles are needed for the residential market.
- Developing surfaces for envelope components able to reversibly switch from non-absorbing low-emittance to highly-absorbing high-emittance.
- There is a need for higher performing insulation and/or reduction in the cost of the most widely available high performance foam insulation in the buildings sector.

Questions - contact Marc LaFrance, 202-586-9142, Marc.Lafrance@ee.doe.gov

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Topic 2: Water Usage in Electric Power Production and Industrial Processes

Thermoelectric power production results in the withdrawal of 195 billion gallons of water per day from rivers and oceans. In thermal power generation, the largest single use of water is for cooling the low-pressure steam from the turbine. Coal fired power plants also use water for the operation of pollution control devices (such as for flue gas desulfurization technology) as well as for ash handling, wastewater treatment, and wash water. Recent studies have suggested that the addition of carbon capture to pulverized coal power plants could double the amount of cooling water necessary for optimal plant operations. Further, the EPA has developed new regulations under 316(b) of the Clean Water Act to reduce this cooling usage of water and improve cooling water intake structures.

Alternative options currently available for power plant cooling can suffer limitations. For example, air-cooled systems (sometimes referred to as dry systems) can incur capital-cost and energy-inefficiency penalties, particularly in retrofit applications. The use of non-potable water for cooling purposes may be accompanied by negative impacts, such as scaling, on existing cooling towers. Other water-related issues associated with power plants involve their wastewater streams, including cooling tower blow-down water in thermoelectric plants and flue gas desulphurization wastewater in coal plants. These are often large volume water flows with low concentration contaminants, making them expensive to treat on a per-contaminant basis**.** Therefore, grant applications are sought to identify novel concepts and technologies to reduce both the amount of water used in thermoelectric power generation and the potential impact on water quality.

Grant applications are sought in the following subtopics:

a. **Water Desalination for Use in Power Plants, Industrial Processes, etc.—**Grant applications are sought to develop improved water treatment technologies and methodologies that can produce the water needed for thermoelectric plants from less than optimum sources, but with the required purity standards. Sources of water of interest include reclaimed waste water, agricultural drainage, brackish or saline ground water, or produced water from other industrial processes.

Specific areas of interest are innovative technologies and methods that:

- Increase the rate of production and lower the cost of producing water.
- Decrease the capital and operating costs of desalination technologies for thermoelectric cooling.
- Reduce plant-material interactions (corrosion and fouling) and improve material compatibility.
- Reduce secondary waste stream generation.

Questions - contact Bhima Sastri, 202-586-2561, Bhima.Sastri@ee.doe.gov

b. Water Cleanup, Recycle and Reuse from Use in Power Plants, Industrial Processes, etc., Before Discharge—Grant applications are sought to develop (1) advanced water treatment technologies and methodologies that produce water with required purity standards through the recycle/reuse of in-plant water, and (2) advanced water treatment technologies and methodologies for waters requiring discharge from the plant to the environment.

Specific areas of interest are innovative technologies and methods that:

- Reduce water discharge and/or minimize environmental impact of discharged waters.
- Reduce water use and discharge impact through novel cooling systems and recycling systems.
- Reduce material interactions (corrosion minimization) and increase robustness of the recycling process.
- Reduce secondary waste streams.

Proposed approaches should offer advantages over existing technologies in terms of water production or cleanup rates, cost (both capital and operating), and other key performance factors.

Questions - contact Jordan Kislear, 202-586-3033, Jordan.Kislear@hq.doe.gov

c. Desalination Using Concentrating Solar Power (CSP)—Rapidly growing populations and rapid depletion of groundwater resources in arid regions of the world require water supply solutions that are affordable, secure, and compatible with the environment. Combined with energy storage or hybrid operation, CSP plants in these high-insolation regions can provide around-the-clock firm capacity that is suitable for large-scale desalination of water either by thermal or membrane processes. Therefore, grant applications are sought for innovative techniques for desalination using any of the four CSP technologies of parabolic trough, power tower, linear Fresnel reflectors, or dish engines. Desalination by any of the first three CSP technologies—troughs, towers, linear Fresnel—confers the additional benefit of providing a source of cooling water that is necessary for plant operation, and grant applications related to these technologies will therefore be given greater weight.

Questions - contact James Kern, 202-586-8109, James.Kern@ee.doe.gov

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Topic 3: Power Plant Cooling

Approximately 90% of the power generation in the United States is provided by thermoelectric power plants (including coal, oil, natural gas, nuclear, biopower, geothermal, and concentrating solar thermal power plants). In thermoelectric power plants, heat is used to create steam, which then turns a steam turbine. A cooling system is then used to condense the steam as part of the thermodynamic cycle. The efficiency of the overall thermodynamic cycle is directly related to the ability to reject heat. Current regulations require that all new thermoelectric power plants must be equipped with either wet re-circulating cooling systems or dry cooling systems, both of which are less efficient than once-through cooling cycles. The Department of Energy is seeking applications for technologies that will improve the efficiency or reduce the cost of power plant cooling systems.

Grant applications are sought in the following subtopics:

a. Advanced Dry or Hybrid Wet/Dry Cooling Systems—Conventional recirculating cooling systems consume large quantities of water in operation, an important constraint in regions where water is scarce. Air-cooled systems do not use water for cooling, but have higher capital costs and suffer limitations on their generating capacity during high temperature days, when the demand for electric power often is the highest. In response to these constraints, the Department of Energy is seeking grant applications to advance the state of the art in both solely dry and hybrid wet/dry cooling systems.

The improved technology should leverage trade-offs between: (1) practical water conservation opportunities; (2) minimizing capital cost and long-term operating costs; and (3) maximizing power plant performance, including by reducing capacity loss during high temperature days and by reducing parasitic power loss. Innovative use of advanced materials and/or fluids for power generation cooling applications would be considered under this proposal, but use of exotic materials should be done to reduce overall costs and minimize environmental impacts of operations and decommissioning, while maximizing the ability to reject heat at the differential temperatures common in most nuclear, fossil and cogeneration power generator condensers, as well as those temperatures common for other applications such as biomass, geothermal, or concentrating solar thermal power systems. These advanced cooling systems should have the ability to perform at a high level under widely varying atmospheric conditions (i.e., under both very humid and very dry conditions). They should also be able to variously accommodate small (10s of MW, such as for geothermal), medium (roughly 50-200 MW, such as for concentrating solar thermal or biomass power), or large (> 500 MW, such as for a large fossil or nuclear plant complex) plant electrical generation capacities.

Grant applications should include a cost/benefit analysis of currently available hybrid, solely wet and/or solely dry systems. This analysis should include an assessment of differences in capital and operating costs as well as other benefits such as water consumption, impacts to water temperature/quality, consideration of visual impacts, air pollutant impacts, etc.

Questions - contact Jordan Kislear, 202-586-3033, Jordan.Kislear@hq.doe.gov

b. Advanced Heat Exchangers for Super-Critical Water Cycle Based Power Plants—Heat exchangers are major power plant components that impact the plant's overall thermal efficiency as well as the power plant's operating costs. The Department of Energy is seeking grant applications to advance the state of the art in heat exchanger design/technology for super-critical

water cycle (above 24 MPa/ 600ºC) based power plants. Increasing operating temperatures and pressures through improved high-temperature strength, creep resistance, and oxidation resistance is one way to achieve increased plant efficiency. Approaches of interest therefore include innovative use of advanced materials and/or designs for heat exchangers servicing super-critical water cycle based power plants. The proposal should include an analysis of the trade offs between heat exchanger efficiency, minimizing capital cost, and minimizing long-term operating costs.
Questions - contact Jordan Kislear, 202-586-3033, Jordan.Kislear@hq.doe.gov

c. Advanced Heat Exchangers for High Temperature, High Pressure Applications—The need for improved efficiency of power systems constantly drives plant design parameters to higher temperatures, pressures and flow rates. Typical shell and tube heat exchangers become severely limited by size (heat transfer area), materials of construction and cost. Grant applications are sought to develop advanced heat exchanger technologies applicable to super critical steam plants, high temperature gas cooled reactor plants, and other high temperature, high pressure power or process related applications. Specific areas of interest are:

- Design of heat exchangers with materials that are creep, erosion and corrosion resistant and are appropriate to the process system. These heat exchangers must be code certifiable for the appropriate plant environments of high temperature (1000 to 1700 F and up), high pressure (up to 3500 psi), and large flow rates.
- Development of domestic technology to fabricate these heat exchangers, develop the required workforce and skill set, test the systems to ensure that they meet the code requirements and the needs of the power systems.

Proposed heat exchanger designs must meet the requirements of the regulatory and enforcement agencies having jurisdiction over the facility. The establishment of a viable US design and manufacturing capability is a goal of this application.

Questions - contact Jordan Kislear, 202-586-3033, Jordan.Kislear@hq.doe.gov

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Topic Area 4 – Advanced Gas Turbines and Materials

Advanced turbine technology and high performance materials are both vital to the development of highly efficient and economic energy systems. Areas of interest include: (a) advanced turbine technology, including innovative high efficiency low-cost modular designs for distributed power systems; (b) high performance materials for nuclear applications; or (c) advanced industrial materials.

Grant applications are sought in the following subtopics:

a. Advanced Turbine Technology for IGCC Power Plants—The Office of Fossil Energy is seeking to advance the design and manufacturability of high temperature materials and hot gas path component cooling techniques, two enabling technologies for high-hydrogen-fired turbine applications, for example, and in Integrated Gasification Combined Cycle (IGCC) power plant systems. Grant applications are sought in the following areas:

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

- Innovative Cooling Approaches: Novel and more effective cooling solutions are needed for the hottest sections of the turbine, including the combustor, transition section, first-stage nozzle, stators, rotor blades, and disks. Therefore, grant applications are sought for research and development to explore innovative surface cooling and internal cooling approaches, which allow ceramic and metal turbine parts to survive in working fluids with higher temperatures. The corresponding manufacturing technology to construct these complex three-dimensional structures with improved aerodynamic and cooling performances is also required. For surface cooling, increased film-cooling effectiveness is needed to improve component durability while decreasing (1) sensitivity to potential surface roughness effects and (2) the propensity to collect deposits in and around cooling-hole exits. For internal cooling, techniques are needed to increase cooling effectiveness and improve component durability, while minimizing cooling air requirements. The effect of proposed approaches on cooling effectiveness should be evaluated for a range of flow-path heat transfer properties (e.g., resulting from higher water vapor levels associated with coal syngas and high hydrogen fuels derived from syngas). These evaluations can be analytical, but experiments to evaluate and demonstrate the proposed approaches and their benefits would be desirable. Successful grant applications will show how a particular cooling technique or approach can be manufactured and incorporated into engine components. Innovative or advanced manufacturing techniques that lead to low cost parts are desirable. This advancement includes the production of tools and techniques to allow the necessary component prototyping for the optimization of an economically viable solution.

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

b. High Performance Materials for Nuclear Application—The Department of Energy is seeking to advance engineering materials for service in nuclear reactors. Grant applications are sought that respond to one of the following areas:

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

- Refractory, ceramic, ceramic composite, graphitic, or coated materials that can be used in the Generation IV Advanced Gas Cooled Reactors Next Generation Nuclear Plant (NGNP) at temperatures above 900°C during normal operations and accidents, in a thermal neutron spectrum environment. These ceramics, graphitic, or coated materials should have the following characteristics: low thermal expansion coefficients, excellent high-temperature strength, excellent high-temperature creep resistance, good thermal conductivity, ability to endure a high neutron fluence environment, ability to be easily fabricated and capable of being joined, low erosion properties in flowing helium, and able to survive air and/or water ingress accidents. Because high temperature strength and corrosion resistance may be difficult to achieve with a single material, composite or coated systems may be required. In addition, grant applications are sought to develop methods for real-time *in situ* monitoring of irradiation performance of these NGNP refractory, ceramic, graphitic, and coated composite materials, including sensors that can monitor the mechanical properties during their service lifetime and during large temperature changes.

- Technologies for the assessment and mitigation of materials degradation in Light Water Reactor systems and components in order to extend the service-life of current light water reactors. Approaches of interest include advanced in situ techniques for monitoring swelling in stainless steel, hardening of reactor pressure vessels and the degradation of concrete, new welding techniques for component repair, methods that can mitigate or predict irradiation and aging effects in reactors and components, and improved nuclear fuel cladding materials.

- Innovative materials and methods to develop materials (metallic alloys in particular) for high temperature applications (1000C range) with improved creep resistance and fabricability (welding, forming, forging, etc) and good corrosion resistance in oxidizing environments. Specific applications for these materials could include heat exchangers and pressure vessels.

- New nondestructive evaluation (NDE) methods to assess the microstructures of materials used in high temperature applications. These materials could include metallic alloys, nuclear grade graphite, carbon-carbon (C/C) composites, and silicon carbide-silicon carbide (SiC/SiC) composites.

- New and robust joining technology (or methodology) for C/C and SiC/SiC composites with complex geometries used in high temperature and radiation fields applications. Specific applications for these materials include in-core components and control rod sleeves.

- New coatings for gas turbine blades with improved thermal protection (to enable increased operation temperature and efficiency) and reduced (outside) surface tension in order to minimize the deposition of particulates responsible for early replacement. The current preferred environment (gas) is helium with small quantities of impurities, including air.

Questions - contact Sue Lesica, 301-903-8755, (sue.lesica@nuclear.doe.gov)

c. Advanced Industrial Materials—Industrial technologies cover a very wide range of unit operations, processes and equipment. To accomplish specific goals of energy efficiency may require materials with different sets of critical engineering properties (physical, chemical, mechanical, electrical, thermal). The success or failure of many industrial energy efficiency concepts depends on materials selection and fabrication techniques to meet the ever increasing demands on performance and life. Grant applications are sought that respond to one of the following areas. The proposed technologies should focus on specific, promising industrial materials technologies that offer the potential for major energy, carbon, and economic benefits.

- Thermal and degradation resistant materials. Grant applications are sought to develop and deploy advanced thermal and degradation resistant industrial materials that last longer and operate at higher temperatures, thereby improving productivity, reducing or eliminating plant down time, and reducing energy intensity. Proposed approaches should seek to develop strategic materials and fabrication techniques that enable an increase in thermal and degradation resistance by a factor of ten (10x) and overcome materials limitations that hinder industrial equipment efficiency.

- Materials for energy systems: Grant applications are sought to develop advanced industrial materials that improve performance of energy production and energy transfer equipment, and reduce energy losses. Areas of interest include but are not limited to refractories and insulation, materials for heat exchangers, or materials for other waste heat recovery technologies. As an example for materials for heat exchanges: utilize low-cost titanium alloys to fabricate heat exchangers for desalination to overcome the corrosion and downtime associated with deterioration of current materials. A 25% improvement over current technologies in the performance and/or longevity of the heat exchangers is desired.

Questions - contact Bhima Sastri, 202-586-2561, (bhima.sastri@ee.doe.gov)

d. Novel Modular Designs for High-efficiency Low-cost Distributed Power Applications— A broad range of flexible fuel distributed power sources offer potentially huge increases in power generation efficiency but are limited by reliability and cost related constraints. Economic drivers and concerns with global climate change create a demand for more efficient modular power systems with less emissions of CO_2 per megawatt hour throughout their expected lifespan, either through inherently robust design, integrated monitoring and controls, or other approaches. Grant applications are sought for high-efficiency, low-cost systems including, but not limited to:

(1) microturbines with combined heat and power applications;
(2) simple cycle machines and CO_2 based fast starting advanced bottoming cycles;
(3) retrofitting approaches to existing machines for increased efficiency of light industrial commercial centers;
(4) improvements to the advanced brayton cycle efficiency; and
(5) advanced natural gas based thermodynamic cycles with high efficiency carbon capture (pre or post combustion).

Questions - contact Bhima Sastri, 202-586-2561, (bhima.sastri@ee.doe.gov)

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Search by Paper No. in citation above.)

Topic 5: Sensors, Controls, and Wireless Networks

Sensors, controls, and wireless networks face technical challenges in fulfilling their potential for the U.S. buildings, power, and industrial sectors. Grant applications for the subtopics listed below should: (1) thoroughly describe the proposed product, subsystem or component and its potential benefits over current technologies; (2) demonstrate, to the extent feasible, that the proposed approach, in a mature configuration, will have a net positive impact on the selected application through performance enhancement or reliability, taking into account such long-term factors as maintenance, refurbishment, replacement, and recycling; and (3) establish a clear, realistic plan for concept development, prototype fabrication, testing, and establishing the partnerships required for successful commercialization.

Grant applications are sought in the following subtopics:

a. Sensors and Wireless Networks for Buildings Applications–High performance buildings require reliable and standardized communications, information technology infrastructure and protocols at both the component and network level. Networks need to be integrated through computerized building management systems that optimize energy use and interface with renewable systems and the grid. Advanced controls should be able to diagnose and correct problems without user intervention, pinpoint operational issues, suggest corrective actions, and potentially dispatch repair technicians. Whole-building advanced control systems, linked to building information models, would enable subsystem optimization to achieve designed energy and environmental performance, increase occupant comfort and productivity, and identify and address operational issues as they arise. A fully integrated building will control lighting, heating, cooling, and ventilation needs based on occupancy, activity and external conditions. DOE seeks to support the development of advanced building control strategies, wireless communications, and information technologies to transform the design, operation, and maintenance of both new and existing buildings. Grant applications are sought to develop new concepts, ideas, and technologies in the following areas:

- Building communications protocols, automated logic control systems, and sensor networks that can provide energy savings in a variety of building types and operational modes.
- Integrated whole-building controls and information technologies for both new construction and retrofits of existing buildings. These controls and technologies are needed to: (1) detect and repair, or alert users to, pending problems; (2) manage and control low-energy buildings; (3) maximize energy storage utilization strategies; (4) maximize energy savings and peak demand reductions; (5) integrate on-site generation and renewable energy sources; and (6) enable two-way communication with the electrical grid (Smart Grid http://www.oe.energy.gov/smartgrid.htm). These advanced whole-building control systems should be capable of automatically detecting and configuring building subsystems and equipment, and components and sensors that have conforming "plug and play" capabilities.
- "Plug and play" capability for building components and equipment. "Plug and play" capability will enable individual components and equipment to interact with integrated

whole-building controls and information technologies to perform all the functions described immediately above, 1-6.

- Integrated modeling and predictive control technologies for whole-building control information technology (IT) software and hardware technologies. These modeling and control technologies are needed to: estimate occupancy; manage system component energy usage; reduce peak energy demand; manage active and passive thermal storage systems; maintain energy storage utilization and potential as a function of building type and climate zone; and control building critical thermodynamic states and systems power consumption.
- Building communications protocols, automated logic control systems and sensor networks that can provide energy savings in a variety of building types and operational modes.

The sensors, controls and wireless networks should themselves also be designed to minimize their power consumption.

Questions—Contact: Richard Orrison, 202-586-1633, Richard.orrison@ee.doe.gov

b. Sensors and Wireless Networks for Industry Applications –In industry, uninterrupted production has always been of paramount importance. Many manufacturing industries operate on narrow profit margins, so any system downtime can have major consequences for profitability. Industrial facilities require systems that perform quickly, reliably, and cost-effectively. Because of this, before committing to any investment in new systems or equipment, plant managers demand demonstrated operational reliability in similar industrial environments. They will not adopt a new technology until they are certain it can deliver real value to their operations.

In some applications, consequences of system faults or failure can be extremely serious, including explosions, personnel injury, toxic releases, or major damage to capital equipment. Developers of sensors, controls and integrated wireless sensor systems will therefore need to work with representatives of the industrial manufacturing community and others to better understand and address concerns. At a minimum, they must resolve key issues regarding technology, collaboration, culture, regulation, and cost.

Sensors, including industrial wireless sensor systems, hold tremendous potential to improve U.S. industrial productivity and product quality. The challenges to achieving the full potential of these systems will require technical advances that tap the expertise and resources of the diverse stakeholders in the technology. Sensor developers, wireless communications suppliers, computer processing specialists, and industrial end-users must work together to develop and demonstrate effective systems that perform successfully in plant operating environments and deliver on the promise.

Grant applications are sought for instrumentation, control sensors and wireless network technologies for industrial operations, especially in the energy intensive and harsh operating environments typically encountered in steel, aluminum, glass, cement, refining, chemicals, etc.

operations. Instrumentation and control sensors, and wireless communication systems, must be reliable and secure. Components must be cost effective and robust. Wireless systems must be secure from radio frequency interference (RFI), electromagnetic interference (EMI), and unauthorized access. The goal is identify and develop advanced sensors and associated control system technologies that will substantially improve industrial process efficiencies, leading to energy efficiency improvements. The following needs are of particular interest:

- robust thermocouple, sensor, and wireless technologies that improve the reliability, security, and accuracy, and optimize the performance of systems and components, especially in energy intensive industries;
- improved cost-effective sensors and integrated diagnostic and monitoring instrumentation to monitor plant equipment energy performance;
- improved robust high temperature sensors that are immune to EMI and RFI in extreme environments;
- analyzers to remotely measure flare combustion efficiency and to identify and quantify the minor (trace) emission products from flares.
- imaging detectors for gaseous species that cannot now be monitored by current generation imaging technology. Examples of industrially important gases include, but are not limited to, hydrogen, hydrogen fluoride, sulfuric acid, and chlorinated gases. The ability to quantify the emissions that are imaged is considered industrially important.
- wireless sensor networks that are compatible with the high-temperature environments of manufacturing plants. Important in this need are electronic components able to withstand the high temperatures encountered in industrial plants such as those used to produce steel and glass.
- interoperable wireless networks for whole-plant monitoring and control, with a goal of optimizing plant efficiency, especially energy efficiency.
- ultra-low power sensors that can extend the battery life and thus the operating life of wireless sensor systems. The low power sensors must be as reliable and accurate as current generation sensors, but consume significantly less energy than typical sensors.

Questions—Contact: Gideon Varga, 202-586-0082, Gideon.varga@ee.doe.gov

c. Sensors and Wireless Networks for Nuclear Power Applications—Grant applications are sought to develop the following instrumentation and control sensors and wireless network technologies for service in current operating nuclear reactor and Generation IV nuclear power systems [Ref. 1-5]. These instrumentation and control sensors and wireless communication systems must be reliable and secure, and wireless systems must also be secure from radio frequency interference and unauthorized access. The components must remain operable during normal operating conditions and anticipated transients, off-normal plant upsets, and reactor accident reactor conditions. The following needs are of particular interest:

- advanced instrumentation, thermocouples, neutron sensors, and wireless applications that improve the reliability, security, and accuracy, and optimize the performance of current nuclear power plant systems and components [5];
- improved diagnostic and monitoring instrumentation for nuclear plant equipment performance and aging;

- improved non-destructive examination or *in-situ* examination methods for nuclear reactor components;
- advanced instrumentation for high neutron flux damage environments in sodium fast reactors [6]; and
- instrumentation for very high temperature gas-cooled reactors, with temperatures greater than 1400° C, neutron flux greater than 10^{14} n/cm^{2}sec, fast neutron fluence greater than 10^{25} n/cm^2, and irradiation damage in the range of 10-20 displacements per atom (dpa) [7,8].

Grant applications are encouraged that propose using the Idaho National Laboratory (INL) Advanced Test Reactor (ATR) National Scientific User Facility [9] for demonstrating irradiation performance; however, technical feasibility and safety must be demonstrated prior to the ATR irradiation testing campaign.

Questions—Contact: Madeline Feltus, 301-903-2308, madeline.feltus@nuclear.energy.gov

d. Integrated Power Line Sensor Systems for the Smart Grid—The existing electric utility infrastructure in the United States lacks the measurement and network technologies required to realize a smart grid. Conventional measurement transformers provide limited bandwidth and have high installation costs. Many non-conventional sensors offer reduced cost and weight, but cannot provide metering class accuracy or extended bandwidth. Further, most non-conventional sensor monitoring points require auxiliary power, which is a significant added installation expense. At present, both new sensors and conventional measurement technologies are typically deployed for a single purpose (e.g. Supervisory Control and Data Acquisition [SCADA], metering, local control, fault location, etc.) with a dedicated communication link.

As a first step in achieving improved reliability and efficiency, multi-function sensor packages must be deployed across power distribution and transmission systems. Typically, a voltage sensor, current sensor, and low-voltage intelligent electronic device must be interconnected and networked with a communication link. A solution that integrates state-of-the-art sensors, metrology, an integrated power source and reliable wireless communication will be necessary to reduce installation time and enhance deployment. Sensor system flexibility is necessary to permit deployment using existing utility infrastructure and utility preferences. Therefore, grant applications are sought to develop integrated, modular sensor solutions with the following requirements:

- Metering class accuracy;
- Wide dynamic range;
- Wide bandwidth to measure high order harmonics and sub-harmonic disturbances;
- Seamless interface to Advanced Metering Infrastructure (AMI) and SCADA systems;
- Self-Powered (energy-harvesting);
- Cost-effective for distribution and transmission level applications; and
- Modular design that allows adaptation to existing utility infrastructure.

These customizable integrated sensor solutions will be required to simultaneously address the following applications: (1) metering; (2) harmonic measurement; (3) low-frequency (sub-60 Hz and quasi-DC) anomalies (e.g. geomagnetic transients); (4) energy theft detection and energy loss detection; and (5) integration of renewable generation (e.g. wind and solar) and microgrids.

Questions – contact Phil Overholt, 202-586-8110, (philip.overholt@hq.doe.gov)

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Topic 6: Advanced Water Power Technology Development

The U.S. Department of Energy (DOE) Wind and Hydropower Technologies Program (WHTP), under the Office of Energy Efficiency and Renewable Energy (EERE), is currently engaged in research and development activities designed to accelerate the technology evolution of advanced water power. Advanced water power technologies include devices capable of extracting electrical power from waves, water currents, and ocean thermal temperature differences. They also include technology advancements that will (1) enable cost-competitive development of new hydropower resources such as hydropower projects built on conduit or water conveyance systems, existing non-powered dams, or small-scale pumped storage projects, or (2) lead to improvements in the efficiency and/or environmental performance of existing hydropower and pumped storage facilities.

Depending on the type of technology and application in question, water power systems are typically developed along a multi-step pathway that can include design concept, scale model development, laboratory testing, open water testing, full-scale open water testing, and finally commercial demonstration. Because many of the technologies in question are relatively new, device developers are frequently involved simultaneously in several high-risk component and subsystem development paths. The success of the entire system rests on successful outcomes from all of the constitutive paths. If one of these subsystem or component pathways fails to produce a result that meets the design requirements of an integrated water power system, that system cannot be fully demonstrated.

This SBIR topic recognizes the complexity of this commercial development situation and is intended to help device developers focus in greater detail on the technical areas of highest risk and uncertainty embodied in their concept. Proposals do not need to be limited to specific device types. Proposals can (1) focus on a component or subsystem of a specified wave, water current, ocean thermal, or hydropower system that will enable the overall system to function; or (2) develop a subsystem or tool that can potentially improve the performance of multiple devices if it can be shown to have broader universal application (e.g. underwater monitoring devices or flow optimization software). In either case, the unique function and innovation of the subsystem or application must be clearly described and its function in relationship to the greater system must be expressed clearly.

The Phase 1 project should focus on high risk hardware development and testing. However, each applicant must demonstrate, through analysis, the viability of the overall concept on the basis of performance and design safety. Applicants are encouraged to submit design plans and accompanying analysis for advancing a design or concept, and must demonstrate an understanding of how to compute the energy capture and extraction potential of a single device in terms of the available energy.

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

Grant applications are sought in the following subtopics:

a. Pumped Storage Hydropower (PSH)—Like conventional hydropower, PSH uses the kinetic energy of water falling from an elevated reservoir to generate power. However, PSH uses reversible turbines that can also pump water back into a reservoir for later use in power generation. When needed, PSH systems can be cycled on or ramped up extremely quickly, providing peaking power better than fossil-fueled plants that require significantly more start-up time. Additionally, PSH can ease load-following and other grid management challenges, and enable the large-scale incorporation of variable renewables such as wind and solar.

Grant applications are sought to pursue new and innovative approaches and/or advances for PSH systems or subsystems, especially those that have combined energy efficiency and environmental benefits. Areas of interest include:

- Reversible turbine/generator assemblies (with a focus on rotor stator interaction, hydroacoustics, cavitation, flow induced vibration and fluid structure coupling).

- Technologies to more efficiently transport water between reservoirs, including consideration of sedimentation, as well as the design and control of pressurized shafts and tunnels.
- Application/optimization of underground reservoirs.

Grant applications that address other areas that advance the state-of-the-art of pumped storage hydropower technologies will also be considered. In addition, subsystems may be proposed that do not address a specific device under development, provided that it can be clearly shown that the subsystems would benefit multiple devices under development generically. In these cases, items 3 and 4 below may not be applicable. Technologies that may be of interest for PHS, but are more broadly applicable to other types of advanced hydropower systems, are identified separately in Subtopic 6-b.

Grant applications should provide: (1) a technical and integrated operational description of a proposed PSH system or subsystem; (2) a description of how the proposed subsystem integrates into an overall project concept and improves on existing technology; (3) an analysis for determining critical design load cases for the overall concept; (4) an analysis of the power performance and energy extraction capability based on available energy; and (5) a discussion that addresses the environmental issues to be encountered or resolved as a result of the technology employed.

Questions - contact Alejandro Moreno, 202-586-8171, Alejandro.Moreno@hq.doe.gov

b. Advanced Hydropower Systems—Advanced hydropower systems are technologies that improve the energy efficiency and/or environmental performance of existing hydropower turbines, generators, dams, and diversions, including those that increase water-use efficiency (i.e., generate more electricity with less water). For the purpose of this subtopic, advanced systems also include new technologies that will enable the cost-competitive development of new hydropower resources, such as hydropower projects built on conduit or water conveyance systems, existing non-powered dams, or scalable pumped storage projects (i.e., with lower flows, heads, or capacity). Some new turbine designs have been proposed recently (e.g., fish friendly designs supported by DOE's Advanced Hydropower Systems Program), but few have been fully tested. Also, automated control technologies and decision support systems, which may offer substantial increases in operational efficiencies along with environmental benefits, have been proposed.

Grant applications are sought to pursue new advances for hydropower systems or subsystems, especially those that have combined energy and environmental benefits. Areas of interest include:

- Advanced electrical components for integration of hydropower with other renewables.
- Fish-friendly turbine designs.
- Variable-speed or high-voltage generators, especially those applicable to innovative and scalable pumped storage projects.
- Cost-effective turbine control systems and flow measurement systems, especially those that can be used remotely or in difficult-to-access flow paths.
- Advanced weirs for flow re-regulation and aeration downstream of power plants.
- High-performance materials and coatings to replace or rehabilitate existing components.

- "Run of river" designs.

Grant applications that address other areas that advance the state-of-the-art of hydropower technologies will be considered. In addition, subsystems may be proposed that do not address a specific device under development, provided that it can be clearly shown that the subsystems can benefit multiple devices under development generically. In these cases, items 3 and 4 below may not be applicable.

Grant applications should provide: (1) a technical and integrated operational description of a proposed hydropower system or subsystem; (2) a description of how the proposed subsystem integrates into an overall project concept and improves on existing technology; (3) an analysis for determining critical design load cases for the overall concept; (4) an analysis of the power performance and energy extraction capability based on available energy; and (5) a discussion that addresses the environmental impact issues to be encountered or resolved as a result of the technology employed.

Questions - contact Alejandro Moreno, 202-586-8171, Alejandro.Moreno@hq.doe.gov

c. Wave and Current Energy Technologies—Wave and current energy technologies have significant potential for utility-scale energy production. However, while dozens of international companies are currently developing systems, only a few commercial scale projects have been deployed worldwide. Grant applications are sought to develop approaches that can advance wave and current energy technologies. Areas of interest include wave energy converters (such as point absorbers, oscillating water column devices, overtopping devices, and attenuators), and energy conversion technologies for tidal, river, and ocean currents (e.g., both axial flow and cross flow turbines are of interest, as well as other methods that can demonstrate reasonable energy conversion efficiency).

Grant applications are sought to pursue the detailed development of new device concepts, and/or selected subsystems or components embedded within a broader concept or device. Sample topics include:

- Moorings, seabed attachments and associated arrangements for wave, tidal and/or current devices and/or arrays. This area includes, but is not limited to, the development of innovative mooring and seabed attachment solutions; design tools for mooring arrays; advanced installation or service equipment; and/or systems/solutions that enhance environmental acceptance.
- Advanced Mechanical Sub-Systems/Components. This area is aimed at increasing the mechanical energy conversion efficiency, environmental performance, survivability and/or reliability of devices, including, but not limited to, turbine blades, rotors or rotor subcomponents; power conversion mechanisms; low friction bearings with high load capability, long life and high tolerance of variable device geometries; mechanical shaft seals with long life in sea water; and the development and/or application of alternative materials/coatings.
- Advanced Electrical Sub-Systems/Components. This area is aimed at increasing the efficiency and reliability of electrical energy generation, transmission, and distribution, including, but not limited to, the design and installation of advanced generator concepts and power electronic converters, optimized device/array power transmission and

conditioning systems, low-cost flexible submerged electrical cables, load mitigation systems, and intelligent condition monitoring systems.

In addition, subsystems and components that do not address a specific device also may be proposed, provided that it is clearly shown that the proposed component or subsystem generically can benefit multiple devices. In these cases, items (2) and (3) below may not be applicable.

Grant applications should provide: (1) a technical and operational description of the proposed device or subsystem (the latter describing how the proposed subsystem integrates into, and enhances, a full energy conversion system); (2) a demonstrated understanding of the design criteria for extreme load conditions and associated load shedding capabilities of the proposed device, or component/subsystem and, if appropriate, the integrated system; (3) an analysis of the power performance and energy extraction capability of the proposed device or component/ subsystem and/or the integrated system, as appropriate, based on available energy; and (5) a discussion that addresses the environmental impact issues to be encountered or resolved as a result of the technology employed.

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d. Advanced Component Designs for Ocean Thermal Energy Conversion Systems (OTEC)—Systems that generate power using the temperature difference between cold deep water and warm surface water were first proposed in 1881 by d'Arsonval and were demonstrated in Cuba as early as 1930 by Georges Claude. However, despite large public and private investments over the years, a viable commercial technology has not yet emerged. Technological challenges to OTEC commercialization include: access to and transport of cold seawater from depth, low thermal conversion rates due to relatively small temperature differences between cold deep seawater and warm surface waters; high capital costs associated with the large scale of conversion equipment; power transmission to shore based facilities; and platform design and mooring in deepwater applications.

Grant applications are sought for research and development to explore advanced concepts, systems, and/or approaches to address these challenges. Areas of interest include:

- OTEC Cold Water Pipe (CWP).
- High performance, OTEC-optimized Heat Exchanger design and manufacture.
- OTEC platforms, including mooring and power transmission solutions.
- Balance of plant components, such as high-volume, high-efficiency sea water pumps; high-efficiency, low-temperature, low-pressure ammonia gas turbines; and/or high efficiency vacuum pumps.

Grant applications should provide: (1) a technical and integrated operational description of the proposed OTEC component/subsystem; (2) a discussion detailing the benefits (cost, performance, etc.) of the proposed component/subsystem, including a comparison with currently available technologies and/or systems; (3) an analysis that considers the long-term performance and life cycle cost associated with operations and maintenance, refurbishment, replacement, and/or recycling, as relevant; and (4) a discussion that addresses the environmental issues to be encountered or resolved as a result of the technology employed.

Questions - contact Alejandro Moreno, 202-586-8171, Alejandro.Moreno@hq.doe.gov

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Topic 7: Smart Controllers for Smart Grid Applications

This topic seeks research and development in microprocessor-based controllers that will enable new products to work with an evolving smart grid infrastructure. A key component of the smart grid infrastructure is the advanced metering infrastructure (AMI), which provides two-way communications between energy service providers and the meters themselves, including all devices in between, for information related to electricity consumption and quality of electricity delivery. This AMI implementation has significantly advanced one functionality of the smart grid, "enabling informed participation by consumers in retail and wholesale electricity markets". A related implementation is needed to catalyze advancement in another smart grid functionality, "enabling new products, services, and markets," which is the focus of this topic area, which seeks smart controllers for household appliances, plug-in vehicles (PEVs—including both electric and plug-in hybrid electric vehicles), and distributed energy generators.

In all three of these developments, the smart controllers must be able to interface with the AMI for two-way communications, i.e., both input (receiving price and grid-condition signals from energy services providers) and output (providing load curtailment/shifting information from appliances, charging/discharging services from PEVs to energy service providers, and availability/dispatch information from the distributed generator to the building appliance and the PEV) communications.

Grant applications are sought in the following subtopics:

a. Smart Controller for Household—Grant applications are sought that develop smart controllers for household electricity-consuming appliances and enable smart grid products and services. In particular, grant applications are sought to develop a universal chipset that can be readily adapted, such as in a plug-in configuration into appliances, to control the operations of multi-vendor appliances (including kitchen and laundry appliances, water heaters, refrigeration equipment, heating and cooling systems, etc.). The control functions should be based on demand management signals, i.e., either pricing signals during peak-pricing periods or grid stress signals during either voltage or current excursion periods. Communication could be implemented via remote control, such as through a phone or other portable device.

Questions – contact Eric Lightner, 202-586-8130, (eric.lightner@hq.doe.gov)

b. Smart Controllers for PEVs—Grant applications are sought that develop smart controllers for PEVs to enable smart grid products and services. For PEVs, development is sought for smart controllers (or smart chargers) to address the two major scenarios where PEV operations are expected to impact grid operations: (1) where PEVs do not add significant power to peak load by regulation, coordination, and/or price incentives of charging practices; and (2) where PEVs help balance on- and off-peak loads by shifting when they are charged and also by providing storage and discharging capacity.

Questions – contact Eric Lightner, 202-586-8130, (eric.lightner@hq.doe.gov)

c. Smart Controller to Enable the Dispatch of Distributed Energy Generators—Grant applications are sought for the development of smart controllers that will enable the dispatch of distributed energy generators, such as rooftop photovoltaics and distributed hydrogen fuel cell systems, and their integration with end-use equipment. In an integrated system, the output of the distributed generator would be monitored and control signals would be sent using a standard protocol to control the demand of the end-use equipment. For example, the smart controller could ensure that a home appliance cycles within an acceptable range of operation to better match the availability of solar energy from a rooftop solar system. The smart controller would also monitor the performance of the distributed generation system and its integration with the smart grid, providing an alert if the performance of the system or its effective integration drops.

Questions – contact Eric Lightner, 202-586-8130, (eric.lightner@hq.doe.gov)

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Topic 8: Advanced Solar Technologies

Solar energy is our largest energy resource and can provide clean, sustainable energy supplies, including electricity, fuels, and thermal energy. The President's economic recovery package emphasized solar energy, among others, as a key element in combating global climate change. Cost-effectively capturing the enormous solar resource is problematic, however. This topic seeks to develop novel, previously untried but commercially feasible, solar concepts and devices.

Grant applications are sought in the following subtopics:

a. Hybrid Solar Energy Systems: Combinations of Photovoltaic, Solar Heat, and/or Solar Cooling—The use of hybrid solar technologies, which combine electrical and thermal energy generation, promises to significantly increase the total operating efficiency of solar panels and reduce system costs and size where the co-generation of heat and electrical power is needed. Additionally this approach offers a variety of secondary benefits such as load shifting (thermal cooling, electrical/thermal ratio adjustment, etc.) and synergistic performance benefits (allowing cells to run cooler, etc.). Therefore, grant applications are sought for hybrid solar energy systems that provide combinations of photovoltaic, solar thermal heat, and/or solar cooling with significant cost and performance benefits compared to current technology. Proposed projects should include a cost and efficiency analysis for comparison to existing standalone photovoltaic systems.

Questions – contact: Alec Bulawka, 202-586-5633, (Alec.Bulawka@ee.doe.gov)
James Kern, 202-586-8109, (James.Kern@ee.doe.gov)

b. Innovative Applications of Solar Energy for Fuels—Using solar energy to produce fuels effectively allows solar energy to be stored and therefore used at controlled times and places. A great deal of research has been done by the international community in such production, with, as yet, no cost-effective technology found. Grant applications are therefore sought for innovative design and development of solar-powered systems that produce fuels. Areas of interest include the production of fuels via high-temperature thermochemical processes, thermally assisted electrolysis (conventional electrolysis is not of interest here), photo-electrochemical processes, or other novel mechanisms.

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James Kern, 202-586-8109, (James.Kern@ee.doe.gov)

c. Concentrating Solar Power (CSP) Systems for Distributed Applications—The current focus of the CSP subprogram is on large-scale systems that can supply power on demand. However, there is also a market for smaller scale CSP technologies that can supply power for residential and commercial applications. These could be either rooftop- or community-based systems that do not require a lot of land and can be sited close to load centers. Grant applications are therefore sought for innovative CSP systems for distributed applications. System designs are required in Phase I, moving on to prototype scale systems in Phase 2, if awarded. Phase 1 grant applications must provide a cost analysis—based on the materials and approaches to be used and on anticipated efficiencies—that would indicate a commercially viable product.

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James Kern, 202-586-8109, (James.Kern@ee.doe.gov)

d. Organic Photovoltaic and Nanotech/Photonics—Grant applications are sought to probe, explore, and structure concise methodologies and sub-assemblies for large-scale, molecular manufacturing of fullerenic and other dopant materials for organic semiconductors, specifically for PV.

Grant applications are also sought to explore nano-techniques that contribute to increasing the efficiency of organic PV beyond the 10% level, thereby leading to cost-effectiveness and commercial viability. Areas of interest include both material nano-transformational contributory techniques as well as passive photonic nano-particle/crystal augmentation.

Grant applications submitted in response to this subtopic should describe concisely and specifically how the approach will be take to Phase-2 and beyond to commercialization.

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Topic 9: Advanced Industrial Technologies Development

Manufacturing is a vital component of the United States' economy, accounting for 12 percent of our nation's Gross Domestic Product, and employing 14 million workers or 10 percent of all jobs in 2008 [1]. The industrial sector is also the largest consumer of energy in the United States, consuming 31 percent of all domestic energy in 2008 [4-6]. U.S. industry is increasingly challenged to remain globally competitive, both in terms of energy and economics. In some cases, energy and related factors are affecting the ability of manufacturing plants' to remain competitive.

The Industrial Technologies Program (ITP) of the U.S. Department of Energy (DOE) is tasked with reducing the energy intensity and carbon emissions of the industrial sector through a multi-pronged approach of research, development, demonstration, and deployment (RDD&D); technology delivery; and strategic partnerships. The program seeks to reduce industrial energy intensity in manufacturing facilities by 25 percent between 2010 and 2020 [2, 3]. ITP offers R&D opportunities for energy-intensive industries and crosscutting technologies that can be applied to plant systems regardless of their industry focus.

ITP has expanded its R&D outreach beyond its recent focus (e.g., chemical, steel, pulp and paper, etc.), to include more industries (e.g., cement, construction, datacenters, food processing) and to include more crosscutting applications (e.g., combustion, distributed energy, fuel and feedstock flexibility, industrial materials of the future, nanomanufacturing, sensors and automation) that can be implemented across a variety of industries.

While US manufacturing must be prepared for potential impacts from the carbon constrained world that we are entering, new business opportunities will arise from the introduction of climate-friendly technologies and products that improve efficiency, reduce energy intensity, and provide more sustainable manufacturing methods. These opportunities have the potential to transform existing U.S. manufacturing, as well nascent and future industries associated with energy efficiency and renewable energy. Therefore, this topic seeks to develop transformational manufacturing technologies to create the next generation of U.S. industrial success. Transformational technologies are broadly defined to include new industrial materials, technologies, procedures, and processes that drastically reduce energy use and/or greenhouse gas (GHG) emissions in manufacturing with no negative effect on production, and do so cost effectively. Of particular interest are approaches that lead to early commercialization and job creation.

Grant applications must: (1) thoroughly describe the proposed product, subsystem or component and its potential benefits over current technologies; (2) to the extent feasible, demonstrate that the proposed approach, in a mature configuration, will have a net positive impact on the selected industry through performance enhancement or reliability, taking into account such long-term factors as maintenance, refurbishment, replacement, and recycling; and (3) establish a clear, realistic plan for concept development, prototype fabrication, testing, and establishing the industry partnerships required for successful commercialization. In addition, grant applications should address the potential public benefits that the proposed technology would provide, including reductions in energy, materials, and/or water consumption, and reductions in pollutant emissions. Finally, grant applications should include a plan for introducing the new technology into the manufacturing sector and achieving widespread technology dissemination.

Grant applications are sought in the following subtopics:

a. Novel Approaches that Significantly Reduce Energy Consumption and Emissions in Cement Pyroprocessing—The greatest opportunities in reducing energy consumption and lowering emissions associated with cement/concrete production can be obtained through improvements in cement pyroprocessing. On average, pyroprocessing systems in the United States operate at about 34% thermal efficiency [1,2]. Also, more than half of the cement industry's emissions result from chemical reactions during the production of clinker. Grant applications are sought for new pyroprocessing technologies (e.g., fluidized bed systems), technologies utilizing waste heat and waste fuels, and other technologies to significantly improve energy and environmental performance in the cement industry.

Grant applications should: (1) demonstrate that the proposed approach will help reduce emissions and improve efficiency, and have limited or no negative impact on overall capital costs; and (2) include an economic analysis that accounts for long-term implications.

Questions – Contact Bhima Sastri, 202-586-2561, (bhima.sastri@ee.doe.gov)

b. Scale-Up of Nano-Material Production—The United States has made considerable investment in nanotechnology research, with applications envisioned for medicine and health, national defense, electronics, and other areas. In addition, the following areas are called out as high priority in the DOE-ITP Nanomanufacturing Initiative [1]: batteries/supercapacitors, light-weight nanocomposites, thermal management materials, catalysts for chemical industries and automotive applications, tribological coatings, solar photovoltaics, and solid state lighting. Nanotechnology is expected to play an important role in these technologies, which not only can produce significant energy savings for US industry or provide new supply, but also have large market potential.

Grant applications are sought to develop low-cost manufacturing processes to expand near-term commercial production of innovative nanomaterials products, such as those listed above. Approaches of interest could include the development of novel process technologies as well as the development of enabling process devices such as for nanoscale metrology and real time process control, nanosensors for thermal or chemical management, or others. Successful integration of nanomaterials into final products typically entails resolving fundamental issues of physics and chemistry and addressing critical challenges associated with dispersion, contamination, consistency, and environmental, health, and safety protocols. To ensure that the full potential of nanotechnology can be achieved, grant applications should address the scale-up of the production of promising nanostructures to commercially useful scales, without losing their unique and valuable properties.

Questions - contact Bhima Sastri, 202-586-2561, (bhima.sastri@ee.doe.gov)

c. Novel Technologies that Utilize Waste Heat from Industrial Processes—Industrial waste heat refers to energy that is generated in industrial processes without being put to practical use. Sources of waste heat include hot combustion gases discharged to the atmosphere, heated products exiting industrial processes, and heat transfer from hot equipment surfaces.

Heat recovery technologies frequently reduce the operating costs for facilities by increasing their energy productivity. Many recovery technologies are already well developed and technically proven; however, there are numerous applications where heat is not recovered due to a combination of market and technical barriers.

Grant applications are sought to develop novel means for enabling waste heat recovery technologies to improve industrial energy efficiency. Grant applications should: (1) specify which industry is targeted and provide a clear and concise justification of why the new process/technology best meets the specific requirements of that application; (2) demonstrate that the proposed approach will have an impact on overall energy efficiency; (3) include an economic analysis that accounts for long-term implications; and (4) demonstrate the ability of the applicant to proceed to a demonstration of technology viability under a Phase II project. Finally, applicants are encouraged to provide evidence of collaborative partnerships with potential users that demonstrate beneficial advantages.

Questions – contact Bhima Sastri, 202-586-2561, (bhima.sastri@ee.doe.gov)

d. Industrial Greenhouse Gas Emissions Reduction—Calls for more than 80% carbon dioxide (CO_2) emissions reductions by mid-century are becoming the norm worldwide; for example, the Obama Administration has stated the intent to reduce carbon emission from 1990 levels by 20% in 2020 and by 80% in 2050. In the United States in 2005, industry accounted for approximately 28 percent of total energy-related CO_2 emissions. Significant reductions of industrial greenhouse gas (GHG) emissions (tracked in CO_2 equivalents) can be attained through changes in energy use, materials, and processes. These reductions are tightly correlated to energy and energy efficiency, which are key GHG reduction strategies.

However, while the use of traditional fossil-based energy sources is directly correlated with CO_2 emissions, there are also a number of industrial gases that when released to the atmosphere exhibit very high global warming potential (GWP) [1, 2]. For example, sulfur hexafluoride (SF_6) is commonly used as a cover gas in the production of magnesium (primary production, casting, and recycling) to form a protective layer on the surface of the molten magnesium [3]. This cover gas protects the melt from atmospheric oxygen, reduces the associated fire hazard, and improves the quality and strength of the final product. However, sulfur hexafluoride has a high GWP; its 100-year time horizon GPW has been estimated to exceed 23,000 on a per molecule basis, as compared to CO_2 with a GWP of 1.

The development of advanced manufacturing technologies could significantly reduce industrial emissions of high GWP gases. Therefore, grant applications are sought to develop transformational technologies that address the emissions of high GWP industrial gases. Of particular interest are technologies that apply to industries which have been identified as being major sources of GHG and high GWP gas emissions [4]. Areas of interest include, but are not limited to:

- Combined energy and GHG reductions in primary aluminum production, including the reduction of electrolytically generated perfluorocarbons (PFCs).
- Replacement of high GWP cover gases used in magnesium production.
- Replacement of high GWP etchant gases used in the production of semiconductors, photovoltaics, LCDs, etc.

Questions – contact Bhima Sastri, 202-586-2561, (bhima.sastri@ee.doe.gov)

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Questions – Contact Bhima Sastri, 202-586-2561, (bhima.sastri@ee.doe.gov)

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Topic 10: Advanced Manufacturing Processes

Manufacturing is a vital component of the United States' economy, accounting for 12 percent of our nation's Gross Domestic Product, and employing 14 million workers or 10 percent of all jobs in 2008.[i] Nonetheless, U.S. industry is finding it increasingly challenging to remain globally competitive. In some cases, factors such as energy are affecting the ability of a manufacturing to remain competitive. The U.S. Department of Energy (DOE) is committed to reducing the energy intensity of the industrial sector through a multi-pronged approach to research, development, demonstration, and deployment (R&DDD); technology delivery; and strategic partnerships.

Grant applications for the subtopics listed below should: (1) thoroughly describe the proposed product, subsystem or component and its potential benefits over current technologies; (2) demonstrate, to the extent feasible, that the proposed approach, in a mature configuration, will have a net positive impact on a selected industry through performance enhancement or reliability, taking into account such long-term factors as maintenance, refurbishment, replacement, and recycling; and (3) establish a clear, realistic plan for concept development, prototype fabrication, testing, and establishing the industry partnerships required for successful commercialization.

Grant applications are sought in the following subtopics:

a. Mitigation of Heat Losses, Fouling, and Scaling in Manufacturing Unit Operations— Heat exchange, fouling, and scaling in key processes such as distillation, evaporation, and crystallization reactors are at the top of energy intensive unit operations in the U.S. industry. It has been observed that energy losses are concentrated in heat exchangers and distillation units, including strippers, fractionators, etc. Condensers, air and product coolers, and heat and refrigeration recovery units all account for a large share of heat exchanger losses. Estimates of the energy consumption by evaporation and crystallization processes in the chemical industry alone account for 1,000 trillion BTU. This energy consumption is second only to distillation. Both evaporation and crystallization involve the processing of salts, which can readily lead to the formation of scales and/or fouling, which in turn impede heat transfer in these processes. This subtopic seeks innovative methodologies, techniques, and/or technologies for dealing with heat losses, fouling and scaling in distillation, evaporation, and crystallization processes. Proposed approaches should result in a step change in the reduction of energy losses in these key unit operations. In particular, grant applications are sought for the development and demonstration of:

(1) enhanced and compact heat exchangers that will lower temperature differences between hot and cold streams in feed/effluent systems, thereby minimizing external exergy losses and improving overall thermal energy recovery;
(2) integrated process equipment and heat transfer systems for use in processes such as distillation (packed and tray columns), reactive distillation and reactors with high heat of reaction—with a primary focus on the development of heat transfer systems that can be integrated within the process equipment and result in improvement of multi-phase flow patterns; and
(3) real-time monitoring systems for mitigation of fouling.

Questions – contact Charles Russomanno, 202-586-7543, charles.russomanno@ee.doe.gov

b. Advanced Distillation and Non-Distillation Processes—Significant quantities of inorganic acids, and all commodity organic chemicals, are purified by distillation at some stage in their manufacture. Distillation accounts for more than 60% of the total process energy used for the manufacture of commodity chemicals and is therefore a meaningful target for improvements in energy efficiency. This subtopic seeks to develop new technologies that can significantly enhance the energy efficiency of existing distillation systems used in the U.S. In particular, grant applications are sought for the following:

(1) Systems integration in commodity chemical manufacture that can be implemented at an attractive cost and can reduce currently needed distillation capacity;
(2) Efficient new integrated or hybrid separation systems, such as distillation and adsorption, distillation and solvent extraction, distillation and crystallization, distillation and reaction, etc. The goal here is to develop hybrid technologies that will improve the efficiency of distillation columns by 20% to 40%, but before developing this approach, the history of commercial attempts to introduce efficient hybrid distillation systems should be carefully reviewed;
(3) Design and development of new column externals, such as the reboiler and the condenser, provided that the technology can be demonstrated at an acceptable cost and payback period;
(4) Processes that take advantage of the excess reactive distillation capacity that may result from regulations on oxygenated fuel additives in the chemical industry, provided that the new processes enhance energy efficiency over the processes replaced; and
(5) Technologies involving non-hybrid, non-distillation unit operations that will bring about

an order-of-magnitude increase in separation efficiencies.

Questions – contact Charles Russomanno, 202-586-7543, charles.russomanno@ee.doe.gov

c. Advanced Dewatering—Separation of water from a feedstock, product, or by-product stream is a common, often energy-intensive function in many industrial manufacturing processes. For example, dewatering processes in the pulp and paper industry, including paper forming and market pulp production, consume on the order of 4 -5 MMBtu/ton of product. Thermal dewatering techniques, while more effective than mechanical techniques for some systems (e.g., where there is a high solids content), require excessive space and capital in addition to consuming large quantities of energy. Many chemical processes (e.g. in reactions involving the neutralization of acids and bases) involve the production of water, which makes the reduction and/or removal of water at the back end of the process a big burden.

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

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

Questions – contact Charles Russomanno, 202-586-7543, charles.russomanno@ee.doe.gov

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