ARPA-E Project Selections – TECHNICAL DESCRIPTIONS

September 29, 2011

These projects have been selected for negotiation of awards; final award amounts may vary.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
1) Plants Engineered to Replace Oil (PETRO)			
University of Massachusetts, Amherst	$1,482,264	Amherst, MA	**Development of a Dedicated, High-Value Biofuels Crop** The University of Massachusetts, Amherst will develop an improved oilseed crop that uses carbon more efficiently than traditional crops. The plant will incorporate features that significantly improve photosynthesis and also allow the plant to produce useful, high-energy fuel molecules directly within leaves and stems, in addition to seeds. This will allow a substantial increase in production of fuel per acre of planted land.
University of California, Los Angeles	$2,206,614	Los Angeles, CA	**Energy Plant Design** The University of California, Los Angeles, will re-engineer plants so that they use energy more efficiently. The team will streamline the process by which green plants convert carbon dioxide into sugar or biofuels. This technology could then be applied broadly, for example to crop plants, to improve yields of grain and biomass.
Donald Danforth Plant Science Center	$5,524,832	St. Louis, MO	**Center for Enhanced Camelina Oil (CECO)** The team led by the Donald Danforth Plant Science Center will develop an enhanced variety of the oilseed crop Camelina that produces more oil per acre. Camelina will be engineered with several genes that allow the plant to use light more efficiently, increase its carbon uptake, and divert more energy to the production of oil, which is stored in seeds and is convertible to fuels. The goal of this project is to combine all of these genes into one engineered variety of Camelina, and to prepare it for field trials.
Texas Agrilife Research	$1,877,584	College Station, TX	**Synthetic Crop for Direct Biofuel Production through Re-routing the Photosynthesis Intermediates and Engineering Terpenoid Pathways** Texas A&M University will address a major inefficiency of photosynthesis, the process used by green plants to capture light energy. Specifically, the team will redirect otherwise wasted energy in plants into energy-dense fuel molecules. The fuel will be readily separated from the plant biomass through

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
			distillation.
Lawrence Berkeley National Lab	$4,839,877	Berkeley, CA	**Developing Tobacco as a Platform for Foliar Synthesis of High--Density Liquid Biofuels** The Lawrence Berkeley National Laboratory and its team will develop tobacco plants with leaves that contain fuel molecules. The team will engineer tobacco with traits conferring hydrocarbon biosynthesis, enhanced carbon uptake, and optimized light utilization. The tobacco will be grown using advanced cultivation techniques to maximize biomass production.
Arcadia Biosciences Inc.	$947,026	Davis, CA	**Vegetative Production of Oil from a C4 Crop** Arcadia Biosciences will modify a number of genes involved in oil biosynthesis to induce grasses to produce vegetable oil. Oil is one of the most energy dense forms of stored energy in plants, and it is a liquid that can be extracted readily, separated, and converted into biodiesel fuel. Arcadia's technology will yield biomass comprised of 20% oil and can be transferred into highly productive energy crops such as sorghum and switchgrass.
University of Illinois	$3,250,000	Urbana, IL	**Engineering Hydrocarbon Biosynthesis and Storage Together with Increased Photosynthetic Efficiency into the Saccharinae** The University of Illinois, Urbana-Champaign team will engineer sugarcane and sorghum to produce and store oil, a biodiesel fuel, instead of sugar. The team will optimize the intensity of the leaf color to more efficiently capture and use sunlight, improving energy yields by up to 50% compared to conventional crops. The team will also crossbreed these crops with the energy grass Miscanthus to increase their geographic range of cultivation.
North Carolina State University	$3,734,939	Raleigh, NC	**Jet Fuel From *Camelina Sativa:* A Systems Approach** North Carolina State University will engineer the oilseed crop Camelina with traits that increase the yield per acre of biodiesel. The project incorporates both an alternative way to capture carbon from air and features that allow the plant to accumulate larger quantities of vegetable oil and other fuel molecules in oilseeds. When combined together, the fuel molecules plus vegetable oil isolated from the plant can be converted into a fuel mixture that is comparable to diesel or jet fuel. This variety of Camelina is expected to produce more fuel per acre of land than other conventional biofuel crops.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
Chromatin, Inc	$5,769,590	Chicago, IL	**Plant-Based Sesquiterpene Biofuels** Chromatin will lead a team to engineer sweet sorghum, a plant that produces large quantities of sugar and requires less water than most crops, so that it can accumulate the fuel molecule farnesene. Genes from microbes and other plants will be incorporated into sorghum to allow the plant to produce up to 20% of its biomass as farnesene, which can be readily converted into a type of diesel fuel. Farnesene will accumulate in the sorghum plants similar to the way in which sugarcane accumulates sugar.
University of Florida	$6,367,276	Gainesville, FL	**Commercial Production of Terpene Biofuels in Pine** The University of Florida project will increase the production of turpentine, a natural liquid biofuel isolated from pine trees. The pine tree developed for this project is designed both to increase the turpentine storage capacity of the wood and to increase turpentine production from 3% to 20%. The fuel produced from these trees would become a sustainable domestic biofuel source able to produce 100 million gallons of fuel per year from less than 25,000 acres of forestland.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
2) Rare Earth Alternatives in Critical Technologies for Energy (REACT)			
Case Western Reserve University	$1,000,000	Cleveland, OH	**Transformation Enabled Nitride Magnets Absent Rare Earths** Case Western University and its team members will use micro-alloying (small amounts of metal additions) added to iron-nitride alloys to maximize its magnetic properties, potentially exceeding the magnetic properties of industrially important rare earth magnets. This new alloy modification will provide stability to a specific iron-nitride structure with phenomenal magnetic properties, potentially achieving the "holy grail" of magnets. This magnet could have the highest energy density made entirely from earth abundant raw materials. If successful in this high-risk, high-reward effort, the ultimate goal of this project is to demonstrate this new magnet system, which contains no rare earths, in a prototype electric motor.
Dartmouth College	$397,433	Hanover, NH	**Nanocrystalline τ-MnAl Permanent** Dartmouth College will create bulk nanocrystalline manganese-aluminum alloys with superior magnetic properties. If successful in this high-risk, high-reward research effort, the ultimate goal of this project is to develop a subsequently scalable process that demonstrates magnetic properties for bulk magnets from this alloy.
University of Houston (National Renewable Energy Laboratory, SuperPower, Tai-Yang Research, TECO-Westinghouse Motor Company)	$3,123,750	Houston, TX	**High Performance, Low Cost Superconducting Wires and Coils for High Power Wind Generators** The University of Houston will develop a new, low-cost superconducting wire that can be used in future advanced wind turbine generators. All generators contain coils of wire (usually made of copper) that conduct electricity. A "superconducting" wire can transport hundreds of times more electric current as a similarly-sized copper wire, and can be used to make a wind turbine generator lighter, more powerful, and more efficient. However, the use of superconducting wire has traditionally been too expensive to use in wind generators. In this project, the team will develop a high-performance superconducting wire and will demonstrate an advanced manufacturing process that, if successful, has the potential to yield a several-fold reduction in wire costs, making superconducting wind generators more practical for widespread deployment.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
Northeastern University (Arnold Magnetic Technologies Corporation, Columbia University, General Motors Research and Development, University of Massachusetts Amherst, University of Nebraska – Lincoln)	$3,439,877	Boston, MA	**Multiscale Development of $L1_0$ Materials for Rare-Earth-Free Permanent Magnets** A Northeastern University led team will develop a process to create bulk quantities of iron and nickel in a unique crystal structure with powerful magnetic properties. This iron-nickel crystal structure is found naturally in meteorites and the team will apply advanced synthesis to artificially create this magnetic material structure. The team will stabilize this desired structure by adding other elements, achieving the properties which previously developed over millions of years as meteorites formed in space. Based on this structure, powerful new magnets will have the potential to be developed with properties exceeding those of scarce and costly rare earth magnets. If successful, the ultimate goal of this project is to demonstrate bulk magnetic properties with subsequently scalable fabrication processes.
QM Power (Oak Ridge National Laboratory, Smith Electric Vehicles, University of Delaware)	$2,319,474	Lee's Summit, MO	**Advanced Electric Vehicle Motors with Low or No Rare Earth Content** QM Power and its partners will develop a new type of electric motor with the potential to efficiently power future generations of advanced electric vehicles. Many of today's electric vehicle motors use expensive, imported rare earth magnets to efficiently provide torque to the wheels. In this project, QM Power and its team will develop a motor that uses no rare earth materials, but is light, compact, and potentially delivers more power than many vehicle motors with greater efficiency at less cost. Key innovations in this project include the use of a new motor design, addition of emerging materials, and the incorporation of advanced manufacturing techniques that substantially reduce costs of the motor.
Pacific Northwest National Laboratory (Ames Laboratory, Electron Energy Corp, United Technologies Research Center, University of Maryland, University of Texas at Arlington)	$2,344,299	Richland, WA	**Manganese-Based Permanent Magnet with 40 MGOe at 200 °C** Pacific Northwest National Laboratory and team will reduce the cost of wind turbines and electric vehicles by developing a new alternative to rare earth permanent magnets based on an innovative composite which uses manganese materials. These manganese composite magnets hold the potential to double the magnetic strength relative to those being used today, with raw materials which are inexpensive and abundant. Members of this research team will develop stronger magnets by leveraging high-performance supercomputer modeling and synthesis experiments of various metal composite formulations that do not contain rare earths. If developed successfully in this high-risk, high-reward effort, these composite magnets will reduce U.S. dependence on expensive

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
			rare earth material imports, reduce the cost and improve efficiency of green energy applications such as wind turbines and electric vehicles.
University of Alabama (University of California at San Diego, Mississippi State University)	$1,265,589	Tuscaloosa, AL	**Rare-Earth-Free Permanent Magnets for Electrical Vehicle Motors and Wind Turbine Generators: Hexagonal Symmetry Based Materials Systems Mn-Bi and M-type Hexaferrite** The University of Alabama led team will demonstrate advanced magnetic properties by the advanced research and development of new magnetic composite materials. These new magnetic materials have the potential to achieve the magnetic properties of current state-of-the-art rare earth magnets, which are essential to the emerging energy industries, without the need for these costly and scarce materials. The ultimate goal of this high-risk, high-reward research project is to demonstrate superior magnetic properties in a bulk magnet with these two material systems.
Argonne National Laboratory (Electron Energy Corporation)	$2,965,904	Argonne, IL	**Nanocomposite Exchange-Spring Magnets for Motor and Generator Applications** Argonne National Laboratory will create a new class of permanent magnets for electric motors for wind turbines and electric vehicles. This metal composite magnet design contains a blend of very small particles embedded in a matrix. The size of the particles is approximately 1,000 times smaller than the diameter of a human hair. Arraying these small magnetic particles in alignment has the potential to create a powerful magnet with reduced use of critical rare earth material. The ultimate goal of this project is to demonstrate this new type of magnet in a prototype electric motor.
Brookhaven National Laboratory (American Superconductor Corporation)	$1,374,975	Upton, NY	**Superconducting Wires for Direct-Drive Wind Generators** In this project, Brookhaven National Laboratory and partner American Superconductor will develop a new, low-cost superconducting wire that can be used in future advanced wind turbine generators. All electricity generators contain coils of wire (often made of copper) that conduct electricity. A “superconducting” wire can transport hundreds of times more electric current than a similarly-sized copper wire, and has the potential to make a wind turbine generator lighter, more powerful, and more efficient. However, the use of superconducting wire traditionally has been too expensive to use in wind generators. In this project, the team will develop a high-performance superconducting wire that can handle significantly more electrical current, and will demonstrate an advanced manufacturing process that, if successful, has the

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
			potential to yield a several-fold reduction in wire costs. These breakthroughs in superconducting wire manufacturing process technologies have the potential to make these advanced wind generators practical for widespread deployment.
Baldor Electric Company (Arnold Magnetic Technologies Corp, ABB)	$2,942,867	Richmond Heights, OH	**Rare Earth-Free Traction Motor for Electric Vehicle Applications** Baldor and partners will develop a new type of electric motor with the potential to efficiently power a next generation class of electric vehicles. Unlike today's electric vehicle motors which use expensive, imported rare earth magnets, in this project, the team will develop a motor that uses no rare earth materials, but is light, compact, and has the potential to deliver more power than today's vehicle motors at a substantially lower cost. Key innovations in this project include the use of an innovative motor design, incorporation of a unique cooling system, and the development of advanced materials manufacturing techniques that if successful has the potential to substantially reduce the costs of an electric motor's rotating components.
General Atomics (University of Texas at Dallas)	$2,819,393	San Diego, CA	**Double-Stator Switched Reluctance Motor (DSSRM) Technology** General Atomics and the University of Texas at Dallas (UT-Dallas) will develop a new type of electric motor with the potential to efficiently power a next generation class of electric vehicles. Unlike many of today's electric vehicle motors which use expensive, imported rare earth magnets, in this project, the team will develop a motor that uses no rare earth materials, but is light, compact, and potentially delivers more power than many of today's vehicle motors at a substantially lower cost. This project will focus on improving the performance and enhancing the manufacturability of the unique "double stator" motor design, which has initially been investigated at UT-Dallas, which can smoothly and efficiently deliver high power to a car or truck.
Virginia Commonwealth University (Arnold Magnetic Technologies, Northeastern University, University of California - San Diego, Moog Inc., Bayer	$2,911,374	Richmond, VA	**Discovery and Design of Novel Permanent Magnets using Non-strategic Elements having Secure Supply Chains** A Virginia Commonwealth University led team will demonstrate a new class of permanent magnets that do not contain any rare earth elements. This team will fabricate a carbide-based composite magnet that will have equivalent performance to the best commercial magnets and be significantly less expensive. The ultimate goal of this project is to demonstrate this new magnet in a prototype electric motor.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
Technology Services)			
University of Minnesota (Oak Ridge National Laboratory)	$2,529,299	Minneapolis, MN	**Synthesis and Phase Stabilization of Body Center Tetragonal (BCT) Metastable Fe-N Anisotropic Nanocomposite Magnet-A Path to Fabricate Rare Earth Free Magnet** A joint University of Minnesota and Oak Ridge National Laboratory interdisciplinary team will aggressively develop an early stage prototype of bulk iron-nitride permanent magnet material. This new material has the potential to be the "holy grail" of magnets as the highest energy density magnet from earth abundant raw materials. This project will provide the basis for an entirely new class of rare earth free magnets for electric vehicle and wind turbine applications capable of eliminating the need for costly and scarce rare earth materials. The ultimate goal of this project is to demonstrate magnetic properties on a prototype bulk magnet exceeding state-of-the-art commercial magnets.
Ames Laboratory (General Motors, Molycorp, NovaTorque)	$2,202,545	Ames, IA	**Novel high energy permanent magnet without critical elements** Ames Laboratory and its team members will develop a new class of permanent magnets based on the element cerium. Cerium is four times more abundant than the critical rare earth element neodynium, which is used today in state-of-the-art magnet material. This project is looking at combining other metal elements with cerium to create a new, powerful magnet. A significant goal of this project is to develop a new magnet that has the high temperature stability required for electric vehicle motors. If successfully developed, this new magnetic material will ultimately be demonstrated in prototype electric motors.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
3) High Energy Advanced Thermal Storage (HEATS)			
NAVITASMAX (Cornell University, Harvard University, Nano Terra, Barber-Nichols)	$812,238	Chandler, AZ	**Concentrating Solar Power/Nuclear: Novel Tuning of Critical Fluctuations for Advanced Thermal Energy Storage** NAVITASMAX will develop a novel heat storage method for solar and nuclear applications that will improve thermal energy density over existing systems by an order of magnitude. This project will evaluate behavior of simple and complex supercritical fluids and tune such fluid systems for increased heat capacity for enhanced heat storage. The team will conduct a one-year "proof-of-concept seedling" program to determine the viability of creating fluids with very high heat capacity, which will provide the potential of developing advanced low cost and efficient thermal storage for solar and nuclear applications.
Abengoa Solar Inc.	$3,598,549	Lakewood, CO	**Concentrating Solar Power/Nuclear: High Efficiency Solar-Electric Conversion Power Tower** Abengoa Solar will develop a high efficiency solar-electric conversion tower that utilizes new system architecture coupled with novel thermal energy storage technology, which will enable low cost, fully dispatchable solar energy generation. Compared to the state of the art parabolic trough with molten salt system, this technology can reduce the system cost by 30% while providing higher performance resulting in reduced cost for renewable solar electricity.
Halotechnics, Inc. (Pratt & Whitney Rocketdyne, Inc)	$3,303,719	Emeryville, CA	**Concentrating Solar Power/Nuclear: Advanced Molten Glass for Heat Transfer and Thermal Energy Storage** Halotechnics will develop a high temperature thermal storage system utilizing a new low cost, earth abundant, and low melting point molten glass as the heat transfer and thermal storage material. This new material will enable unprecedented efficiency with thermal energy storage and has the potential to reduce costs by a factor of ten when developed and deployed at commercial scale. Halotechnics will optimize the material in order to develop a complete system to pump, heat, store, and discharge the molten glass. If successful, this technology will enable low cost and efficient thermal energy storage for concentrating solar and nuclear power applications.
University of Utah (HRL, General Motor Global R&D)	$2,677,688	Salt Lake City, UT	**Electric Vehicle: A New Generation of High Density Thermal Battery Based On Advanced Metal Hydrides** A project team from the University of Utah will develop an

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
			advanced metal hydride based compact hot and cold battery for climate control in automobiles. The overarching goal of the project will provide heating and cooling to electric vehicles (EVs) without draining the electric battery, in effect, extending the driving range of EVs per electric charge.
Pacific Northwest National Laboratory (University of South Florida, Tampa)	$803,142	Richland, WA	**Electric Vehicle: Electric-Powered Adsorption Heat Pump for Electric Vehicles** Pacific Northwest National Laboratory (PNNL) will develop a new class of advanced nanostructured materials called "metal-organic frameworks (MOFs)." These MOFs will have larger sorption capacities and can be regenerated electrically (EMOFs). This will provide a new electric power driven adsorption cycle for a highly efficient heat pump for electric vehicles (EVs). This research and development effort will help in bringing a new electric powered adsorption heat pump for EVs to the marketplace.
Sheetak Inc. (Delphi Automotive, LLP)	$4,675,834	Austin, TX	**Electric Vehicle: Thermoelectric Reactors for Efficient Automotive Thermal Storage (TREATS)** Sheetak Inc. will develop a new HVAC (heating, ventilation, and air conditioning) system for electric vehicles to store the energy required for heating and cooling for electric vehicles (EVs). This system combines Sheetak's novel solid state thermoelectric energy converters to recharge the hot and cold battery while the vehicle is parked and while the electrical battery is being charged. These converters can also run on the electric battery and provide the required cooling and heating to the passengers, eliminating the need for a traditional compressor and inefficient heaters used in today's EVs.
Pacific Northwest National Laboratory (University of Utah)	$712,511	Richland, WA	**Concentrating Solar Power/Nuclear: Reversible Metal Hydride Thermal Storage for High Temperature Power Generation Systems** Pacific Northwest National Laboratory (PNNL) will exploit recent breakthroughs with new materials and system designs to demonstrate proof of concept for hydride-based thermal energy storage (TES). The team will reduce the hydride based TES technology risk in two ways: first, by demonstrating the desired cycle life in a reversible hydride at high temperature; and second, through demonstration of a prototype. The successful hydride based TES system will result in an order of magnitude increase in storage density as compared to the current state of the art systems.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
The University of Texas at Austin (SINOEV)	$2,481,301	Austin, TX	**Electric Vehicle: Thermal Batteries for Electric Vehicles** The University of Texas at Austin (UTA) will lead the research and development of high-energy density, low-cost thermal storage systems, based on new composite phase change materials (PCMs). This material development will lead to energy density 2 to 3 times more than that for the state of the art PCMs for low temperature applications. The developed materials will be used to design a hot and cold battery for EVs. This transformative and disruptive technology can increase the penetration of EVs into the automobile market.
University of South Florida (SunBorne Energy)	$2,439,450	Tampa, FL	**Concentrating Solar Power/Nuclear: Development of a Low Cost Thermal Energy Storage System Using Phase Change Materials with Enhanced Radiation Heat Transfer** The University of South Florida team will develop low cost industrially scalable high temperature phase change materials (PCMs) for thermal energy storage (TES) system. An innovative electroless encapsulation technique will be used to enhance the heat transfer to overcome the low thermal conductivity of common PCMs. The proposed research will result in the development of an innovative high temperature and smaller footprint TES system at a low cost representing almost a 75% reduction in the cost of TES.
Massachusetts Institute of Technology	$2,966,654	Cambridge, MA	**Thermal Fuel: HybriSol Hybrid nanostructures for high-energy-density solar thermal fuels** Using innovative nanomaterials, MIT will develop a thermal energy storage device, or a heat battery, that captures and stores energy from the sun to be released onto the grid at a later time. This energy storage device called “HybriSol” is transportable like fuels, 100% renewable, rechargeable like a battery and emissions-free. In addition, “HybriSol” can be used without a grid infrastructure for applications such as heating and water purification. If successful, this heat battery could have an unprecedented impact on efforts to decrease fossil fuel consumption and emissions, enabling clean solar energy to be accessible 24 hours a day.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
Massachusetts Institute of Technology (Boston College)	$874,679	Cambridge, MA	**Concentrating Solar Power/Nuclear: Metallic composites phase-change materials for high-temperature thermal energy storage** MIT and Boston College will develop phase change materials (PCMs) based thermal energy storage (TES) materials to achieve high energy efficiency for the TES system using novel thermodynamic phenomena. The PCMs will have high phase change temperatures, high thermal conductivity values, long lifetime and low cost. The team will develop the PCMs through characterization and modeling the properties of these materials. The successful project will enable continuous power supply from concentrated solar-thermal power (CSP) systems and nuclear plants with base and peak power capacity.
Regents of the University of Minnesota (California Institute of Technology, Abengoa Solar Inc)	$3,599,792	Minneapolis, MN	**Thermal Fuel: Solar Fuels via Partial Redox Cycles With Heat Recovery** A team of experts from the University of Minnesota will develop technology for a solar thermochemical reactor to make fuel production more efficient. The team will achieve unprecedented solar-to-fuel conversion efficiencies of more than 10% by combined efforts and innovations in material development, and reactor design and demonstration. The proposed technology will effectively utilize vast domestic solar resources to produce precursors to synthetic fuels (e.g. gasoline). If successful, it could decrease or even completely eliminate the dependence on foreign oil imports.
United Technologies Research Center (Ricardo, Inc)	$2,695,930	East Hartford, CT	**Electric Vehicle: Thermal Storage Using Hybrid Vapor Compression Adsorption System** United Technologies Research Center (UTRC) will develop a hybrid vapor compression adsorption systems with thermal storage. The hybrid system will efficiently store thermal energy, and will be lighter and more compact compared to current heating and cooling systems. The team will use a unique approach of adsorbing a refrigerant on a metal salt, which has a high mass and volumetric capacity tailored to the refrigerant. The proposed project outcome will be a hot and cold battery that provides comfort to the passengers with minimum electricity utilization from the electric batteries during the drive cycle. This would extend the driving range of the electric vehicles or plug-in hybrid electric vehicles.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
University of Florida	$2,975,920	Gainesville, FL	**Thermal Fuel: Solar Thermochemical Fuel Production via a Novel Low Pressure, Magnetically Stabilized, Non-volatile Iron Oxide Looping Process** The University of Florida will develop a new dual cavity, high temperature chemical reactor that converts concentrated solar thermal energy to Syngas, which can be used to process gasoline. The overarching project goal is lowering the cost of the solar thermochemical production of Syngas for clean and synthetic hydrocarbon fuels like petroleum. The team will develop processes that use water and recycled CO_2 as the sole feed-stock and concentrated solar radiation as the sole energy source. Successful large scale deployment of this solar thermochemical fuel production will be the key in accomplishing the mission to enhance the nation's economic and energy security by replacing imported oil with domestically produced solar fuels.
Massachusetts Institute of Technology (University of Texas Austin, University of California Los Angeles, Ford Motor Company)	$2,700,000	Cambridge, MA	**Electric Vehicle: Advanced Thermo-Adsorptive Battery Climate Control System (ATB)** MIT will develop advanced adsorption-based hot and cold batteries for effective climate control of electric vehicles (EVs). These batteries will have high cooling and heating storage and fast charging times. The hot and cold battery completely eliminates the need for a vapor compression cycle. It can handle peak heating and cooling loads and attain continuous operation beyond the initial charged capacity. If successful, the technology can also be broadly applicable to residential and commercial buildings, where there are substantial needs to deliver energy in the form of heating and cooling while displacing electricity consumption during peak demand times.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
4) Green Electricity Network Integration (GENI)			
Texas Engineering Experiment Station (University of California Berkeley, Arizona State University, Lawrence Livermore National Laboratory, Grid Protection Alliance, Tennessee Valley Authority, Telcordia, Oak Ridge National Laboratory)	$4,910,031	College Station, TX	**Robust Adaptive Topology Control (RATC)** Historically, the electric grid was designed to be passive, causing electric power to flow along the path of least resistance. The Texas Engineering Experiment Station team will develop a new system that allows real-time, automated control over the transmission lines that make up the electric power grid. This new system would create a more robust, reliable electric grid, and reduce the risk of future blackouts, potentially saving billions of dollars a year.
Oak Ridge National Laboratory (University of Tennessee – Knoxville, Waukesha Electric Systems, Inc.)	$2,000,000	Oak Ridge, TN	**Magnetic Amplifier for Power Flow Control** Complete control of power flow in the grid is prohibitively expensive, which has led to sub-optimal, partial control. Oak Ridge National Laboratory will develop a magnetic based valve-like device for full power flow control. The controller will be inherently reliable and cost-effective, making it amenable for widespread distributed power flow control. The benefits are far-reaching, including full utilization of power system assets, increased reliability and efficiency, and more effective use of renewable resources.
Michigan State University	$2,400,000	East Lansing, MI	**Transformer-less Unified Power Flow Controller for Wind and Solar Power Transmission** Michigan State will develop a *unified power flow controller* (UPFC) that will have enormous technological and economic impacts on controlling the routing of energy through existing power lines. The UPFC will incorporate an innovative circuitry configuration that eliminates the transformer, an extremely large and heavy component, from the system. As a result, it will be light weight, efficient, reliable, low cost, and well suited for fast and distributed power flow control of wind and solar power.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
Charles River Associates (PJM Interconnection, Boston University, Tufts University, Northeastern University, Polaris Systems Optimization, Paragon Decision Technology)	$1,338,591	Boston, MA	**Transmission Topology Control for Infrastructure Resilience to the Integration of Renewable Generation** Charles River Associates will develop decision support technology that will improve the efficiency of the electrical grid by implementing appropriate short term changes of transmission line status, i.e., by controlling the configuration of the transmission grid. The changes will relieve transmission congestion, as well as provide additional tools and controls to operators to manage uncertainty, thus enabling higher levels of renewable generation.
General Electric Company-Global Research (North Carolina State University, Rensselaer Polytechnic Institute)	$4,487,156	Niskayuna, NY	**Resilient Multi-Terminal HVDC Networks with High-Voltage High-Frequency Electronics** Some advanced transmission technologies require expensive power conversion stations to interface with the grid. GE Global Research will collaborate with North Carolina State University (NCSU) and Rensselaer Polytechnic Institute (RPI) to develop a prototype transmission technology that incorporates an advanced semiconductor material, silicon carbide. This prototype will operate at a high voltage level appropriate for the grid. It will decrease the cost and complexity of advanced transmission systems as well as improve efficiency.
Georgia Tech Research Corporation (OSISoft)	$2,000,000	Atlanta, GA	**Prosumer-Based Distributed Autonomous Cyber-Physical Architecture for Ultra-reliable Green Electricity Internetworks** Georgia Tech will develop and demonstrate an internet-like, autonomous control architecture for the electric power grid. The architecture has distributed intelligence, autonomously coordinating control within a network that includes energy production units, storage units, and consumers (homes, buildings, microgrids, utility systems). It will reduce constraints on grid control and enable massive penetration of distributed energy resources (primarily wind and solar power) and storage devices (such as batteries).
California Institute of Technology (Southern California Edison)	$1,350,000	Pasadena, CA	**Scalable Real-time Decentralized Volt/VAR Control** Caltech will develop scalable, real-time, decentralized methods for power control to achieve system-wide efficiency, stability, reliability, and power quality in the presence of uncertain renewable generation. The distributed control architecture will allow each of the end nodes to effectively manage their own power, while at the same time optimizing overall power flow within the grid. This will enable an interconnected system with millions of active energy applications, such as distributed wind and solar power units.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
Varentec, Inc. (Georgia Institute of Technology / NEETRAC, Waukesha Electric Systems, Electric Power Research Institute)	$4,025,951	San Jose, CA	**Compact Dynamic Phase Angle Regulators for Transmission Power Routing** Varentec will develop a compact, low-cost solution for controlling power flow on transmission networks. The technology will enhance grid operations through improved asset utilization and by dramatically reducing the number of transmission lines that have to be built to meet increased renewable energy penetration. Finally, the ability to affordably and dynamically control power flow will open up new competitive energy markets which were not possible under the current regulatory structure and technology base.
Cornell University (Washington State University)	$1,300,000	Ithaca, NY	**GridControl: A Software Platform to Support the Smart Grid** Cornell University will create software that will reduce the time and difficulties required to prototype and demonstrate new smart-grid control methods. The project will enable cloud computing capabilities that are more responsive, secure, and accurate for grid control.
General Electric Company-Global Research	$799,958	Niskayuna, NY	**Nanoclay reinforced Ethylene-Propylene-Rubber for low cost HVDC cabling** Dielectric materials for transmission cables are very costly. The key challenge leading to the high cost is the reliability of the insulation. GE will embed nanomaterials into specialty rubber, e*thylene-propylene rubber,* to develop a new formulation with an optimal combination of orientation, spatial distribution, and electrical properties, leading to highly reliable cabling.
University of Washington (University of Michigan)	$1,423,330	Seattle, WA	**Energy Positioning: Control and Economics** The University of Washington will develop control technologies for energy management. The technology will intelligently decide if excess energy from renewable energy sources should be consumed or directed to storage facilities. If directed to a storage facility, the control technology will also decide to route the energy to a location that is best positioned for later use. The coordinated control of well-positioned and properly sized storage facilities and demand response will facilitate the large-scale integration of renewable generation, significantly reduce the need for transmission expansion, and improve system reliability.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
General Atomics (Mississippi State University)	$2,515,673	San Diego, CA	**Magnetically Pulsed Hybrid Breaker for High-Voltage Direct Current (HVDC) Power Distribution Protection** General Atomics will develop a low loss, high reliability power routing technology that operates about 10 times faster than conventional technology. This technology will be a key enabler of advanced transmission networks, which will play a vital role in linking remotely located renewable energy sources like offshore wind farms and solar energy fields to consumers in urban centers.
AutoGrid, Inc. (Lawrence Berkeley National Laboratory, Columbia University)	$3,465,626	Cupertino, CA	**Highly Dispatchable and Distributed Demand Response for the Integration of Distributed Generation** AutoGrid, Inc., in conjunction with Lawrence Berkeley National Lab and Columbia University, will design and demonstrate a highly distributed Demand Response Optimization and Management System for Real-Time (*DROMS-RT*). The project will enable "personalized" price signals to be sent to millions of customers in extremely short timeframes. This will allow customers to reduce their demand when the grid is congested. DROMS-RT is expected to provide a 90% reduction in the cost of operating demand response programs in the United States.
Smart Wire Grid, Inc (Boeing, Innoventor, New Potato Technologies, Inc., Georgia Tech/NEETRAC, Carnegie Mellon University)	$4,400,000	San Francisco, CA	**Distributed Power Flow Control Using Smart Wires for Energy Routing** Over 660,000 miles of transmission line exist within the continental United States with roughly 33% of these lines experiencing significant congestion. This congestion exists while, on average, only 45-60% of the total transmission line capacity is utilized. A team led by startup company Smart Wire Grid will develop a solution for controlling power flow in the transmission grid to better take advantage of the unused capacity. The power controller will be a "smart wire" that incorporates advanced control software, sensors, and communications technologies.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
5) Solar Agile Delivery of Electrical Power Technology (Solar ADEPT)			
SiCLAB, Rutgers University, NJ	$897,955	New Brunswick, NJ	**First in Class Demonstration of a Completely New Type of SiC Bipolar Switch (15kV-20kV) for Utility Scale Inverters** SiCLAB will improve power switches resulting in substantially better performance in power converters. Simultaneous weight, size and energy loss reduction up to 75% is possible along with improved system reliability and lower costs if the proposed power switch can be developed for use in high voltage and high power systems. This high-risk, high reward program could find transformational applications to utility scale inverters, wind turbine, oil-free solid state transformers, railway traction, smart grid and other applications.
Transphorm Inc. (Enphase Energy Inc.)	$3,644,559	Goleta, CA	**Four quadrant GaN switch enabled three phase grid-tied microinverters** Transphorm will develop a robust, cost effective, high efficiency power transforming device that will be integrated into solar panels. This technology is based on innovative high performance architecture, called a four quadrant switch, enabling a single semiconductor device to switch voltage and current in both directions. It will be made with an advanced semiconductor device material, Gallium Nitride (GaN). The four quadrant design will result in reduced losses and higher efficiency. This "plug-n-use" technology will enable reliable power transfer from solar panels to the grid and revolutionize photovoltaic deployment in commercial establishments and solar farms.
University of Colorado Boulder (National Renewable Energy Laboratory)	$1,200,000	Boulder, CO	**Wafer-Level Sub-Module Integrated DC/DC Converter** The University of Colorado team will develop and demonstrate advanced power conversion technologies at a small scale, suitable for integration into solar panels. The technology is based on very fast switching configurations employing low-loss power transforming devices. The power conversion devices will yield significantly improved energy capture in solar power systems and can be embedded in panels of all types – crystalline, laminate, or flexible.
Ideal Power Converters (Rensselaer Polytechnic Institute, Virginia Polytechnic Institute)	$2,500,000	Spicewood, TX	**Dual Bi-directional Silicon IGBTs Modules enables breakthrough PV Inverter using Current-Modulation Topology** Ideal Power Converters is developing light-weight electronics to connect photovoltaic solar panels to the grid. Their

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Project Title*** **Project Description**
			technology explores innovative circuits using revolutionary transistor designs to develop solar panel electronics for commercial-scale buildings that are compact enough to be installed on walls or roof-tops. The project goal is to reduce the weight of these electronics by 98%, reducing the cost of materials, manufacturing, shipping and installation, and supporting the aggressive cost-reduction goals of the Department of Energy's SunShot Initiative.
SolarBridge Technologies, Inc. (University of Illinois at Urbana-Champaign)	$1,750,000	Austin, TX	**Scalable Submodule Power Conversion Methods for Power Density, Efficiency, Performance, and Protection Leaps in Utility-scale Photovoltaics** SolarBridge Technologies will research and develop a prototype of a new electronic technique for improving the output of solar panels. The technique is specifically aimed at large solar power plants, where many solar panels are connected together. The new technology is "differential power processing," or DPP. The DPP technique involves correcting for the power differences that inherently occur when two solar modules, encountering different amounts of sun, are connected together. The power conversion device incorporating DPP will be much smaller and cheaper than current electronic solutions.
Satcon Technology Corporation (Mide Technology Corporation, Cree Inc., Sandia National Laboratories, Powerex Inc.)	$3,000,000	Boston, MA	**Agile Direct Grid Connect Medium Voltage 4.7-13.8 kV Power Converter for PV Applications utilizing Advanced Wide Band Gap Devices** Satcon Technology Corporation will develop a high power conversion device capable of taking utility-scale solar power and outputting it directly to the electric utility grid at a much higher voltage. The developed technology will replace the large power transformers that are currently necessary with a very compact, lightweight single device. This will result in cost reductions in large solar utility projects, and will enable a wider adoption of PV generating plants
Carnegie Mellon University (Los Alamos National Laboratory, Magnetics (a Division of Spang & Co.), University of Pittsburgh)	$1,722,400	Pittsburgh, PA	**Nanocomposite Magnet Technology for High Frequency MW Scale Power Converters** Carnegie Mellon University's Materials Science and Engineering Department will develop a new nanoscale magnetic material for energy conversion systems with direct grid connection. The magnetic material will reduce the size, weight, and materials cost associated with the power conversion system. It will also contribute to efficient, cost-effective, and reliable grid integration of solar photovoltaics.