ARPA-E Project Selections

July 12, 2010

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)	***Technology Focus – Application: Project Title*** **Project Description**
1) Agile Delivery of Electrical Power Technology (ADEPT)			
Arkansas Power Electronics International, Inc. (University of Arkansas, ORNL, Toyota, Cree)	$3,914,554	Fayetteville, AR	*Circuit Topology/Switches - Automobiles: Low-Cost, Highly-Integrated Silicon Carbide (SiC) Multichip Power Modules (MCPMs) for Plug-In Hybrid* Charging modules for plug-in hybrid electric vehicles (PHEVs) require power electronics that are small, low cost, and efficient and reliable at high temperatures so that additional cooling becomes unnecessary. As electric vehicles become more prevalent, higher power levels will become necessary to enable rapid battery charging. This project will develop and demonstrate a transformational, highly-efficient, ultra-compact silicon carbide PHEV charger.
Case Western Reserve University (G&S Titanium, Evans Capacitor Company)	$2,254,017	Cleveland, OH	*Capacitors - Automobiles: High-Power Titanate Capacitor for Power Electronics* This project will develop novel capacitors for power electronics in the hybrid electric vehicle and consumer electronics markets. The capacitors are designed with metallic glass that allows spontaneous self-repair. This self-repair allows the devices to be driven to higher voltages and thereby achieve higher energy density. The market for capacitors in power applications is $1.6 billion per year.
Cree, Inc. (Powerex, North Carolina State, ABB, Naval Research Lab)	$3,736,291	Durham, NC	*Switches - Transmission: 15 kV SiC IGBT Power Modules for Grid Scale Power Conversion* The purpose of this project is to demonstrate advanced transistor based electrical substations that can help make the electrical grid more flexible and controllable. These novel substations will be enabled by record high voltage (15-20kV) transistors using Silicon Carbide (SiC). These advanced transistors enable the replacement of today's heavy (8000lb) transformers used for electricity distribution, with much smaller, suit-case size (100lbs) electronic transformers.
CUNY Energy Institute (Columbia University, UC Berkeley)	$1,568,330	New York, NY	*Capacitors - Lighting: Metacapacitors* This project will develop a novel electrically insulating material for a new breed of capacitors that increases the capacitor's storage capability and allows for low-cost, efficient grid interfaces for applications from solid-state lighting to solar photovoltaics. The thin film capacitor can be printed in rolls similar to newspaper printing. Transistors and are sealed into

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			these capacitor films to form Metacapacitors. The resulting Metacapacitors are a flexible fabric for electrical power conversion.
GE Global Research (Dartmouth University)	$949,545	Niskayuna, NY	*Magnetics - Photovoltaics: Nanostructured Scalable Thick-Film Magnetics* This project will develop a novel magnetic component that supports compact power interfaces between solar photovoltaics and the electrical grid. This new component uses nanostructured magnetic materials scaled to millimeter dimensions.
GeneSiC Semiconductor (Dow Corning, University of Illinois-Chicago, Bonneville Power Administration, Sandia National Labs)	$2,450,000	Dulles, VA	*Switches - Transmission: Monolithic Silicon Carbide Anode Switched Thyristor for Medium Voltage Power Conversion* This project will develop novel semiconductor technology that will allow efficient processing of Megawatts of electrical power with digital precision. Specifically, high-voltage switches in silicon carbide will be developed and will enable precise control of the electricity infrastructure.
Georgia Tech Research Corporation (National Semiconductor)	$999,017	Atlanta, GA	*Magnetics - Consumer Electronics: Highly Laminated, High Saturation Flux Density Magnetic Cores for On-Chip Inductors in Power Converter Applications* The goal of this project is to greatly reduce the size and cost, and increase the efficiency of, laptop power supplies and other chargers used to power consumer electronics. It will do so through the development of new magnetic materials that support high-currents despite their small size. New manufacturing technologies are employed to create microscale laminates, forming them into inductors and transformers, and integrating them with specialized electronic components to make very small-scale power converters.
Georgia Tech Research Corporation	$981,619	Atlanta, GA	*Circuit Topology/Switches - Transmission: Dynamic Control of Grid Assets Using Direct AC Converter Cells* Technology developed in this project will enable dramatic cost reductions in smart grid implementation and allow increased penetration of renewable energy resources by reducing transmission and distribution upgrade costs by up to 80%. The project will involve several key developments: a new converter layout that achieves an AC/AC function using minimal number of switches, and the elimination of large capacitors in the system.

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HRL Laboratories, LLC (GM, Va Polytech, ORNL, Teledyne)	$5,058,803	Malibu, CA	*Switches – Automobiles: Gallium-Nitride Switch Technology for Bi-directional Battery-to-Grid Charger Applications* The purpose of this project is to develop efficient, compact, and low-cost battery chargers for electric cars. This compact battery charger will support two-way power flow enabling the electrical grid to access the vehicle's battery. More specifically, it will utilize an advanced semiconductor material called Gallium Nitride (GaN) grown on inexpensive silicon to form high voltage switches.
Massachusetts Institute of Technology (Dartmouth, Georgia Institute of Tech, U Penn, OnChip Power)	$4,414,009	Cambridge, MA	*Switches/Magnetics - Lighting: Advanced Technologies for Integrated Power Electronics* This project radically improves the size, integration, and performance of power electronics for high-efficiency solid-state lighting (SSL), with a focus on circuits for interfacing with grid-scale voltages (>100 V) at power levels of 10 – 100W. Specifically, it will develop Gallium Nitride on Silicon (GaN-on-Si) high-voltage transistors, nano-structured magnetic components, and advanced circuit designs.
Teledyne Scientific & Imaging (Flextronics, RPI, Teledyne Lighting & Display Products, Anthony International)	$3,439,494	Thousand Oaks, CA	*Magnetics/Switches - Lighting: Integrated Power Chip Converter for Solid State Lighting* This project will develop a single integrated circuit that will convert the 120V AC from an electrical outlet to direct current required for LED lighting. The power supply uses high-performance, integrated capacitors and transformers on the same chip as high-voltage transistors. Making a cheaper, easily mass-produced LED driver is expected to accelerate the adoption of energy-efficient solid-state lighting.
Transphorm Inc (Kroko, Evans Analytical, UCSB Nanotech, Consultant Magnetics, Stacia Keller)	$2,950,000	Goleta, CA	*Switches - Motors: High Performance GaN HEMT Modules for Agile Power Electronics* This project seeks to foster the adoption of energy-efficient, variable speed motors that are employed in industrial uses from industrial automation to air-conditioning. These compact motor drives will utilize the first hybrid multichip power operating at high frequency (1 megahertz), using efficient high-voltage gallium nitride grown on silicon.
Virginia Tech (U of Florida, UT-Dallas)	$900,000	Blacksburg, VA	*Magnetics/Capacitors - Consumer Electronics: Isolated Converter with Integrated Passives and Low Material Stress* This project will develop a single-chip power supply mobile applications, such as netbooks. The chip converter will include the integration of a transformer, novel capacitors, and transistors, with nano-magnetic material dispensed with high precision by low-cost inkjet printing. The resulting highly efficient (greater than 90%) converters with high power density will reduce the tera-watt-hours of energy consumed by notebooks and netbooks annually.

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Virginia Tech (University of Delaware, International Rectifier)	$983,000	Blacksburg, VA	*Magnetics/Switches - Consumer Electronics: Power Supplies on a Chip (PSOC)* This project is focused on a high-voltage, high-current integrated circuit to power future generations of microprocessors, graphic cards and memory devices. This chip-scale power supply uses new high-voltage transistors using gallium nitride on silicon integrated with new magnetic components.
2) Building Energy Efficiency Through Innovative Thermodevices (BEET-IT)			
ADMA (Pacific Northwest National Laboratory, Texas Engineering Experiment Station-Texas A&M University)	$3,269,965	Hudson, OH	*Dehumidification: High-Efficiency, on-Line Membrane Air Dehumidifier Enabling Sensible Cooling for Warm and Humid Climates* In warm and humid climates, the efficiency of air conditioning decreases significantly in removing the moisture out of the air. This project proposes to dehumidify moist air using a metal foil-like, paper-thin membrane - comprised of a thin layer of ceramic material deposited on a porous metal sheet - that selectively sieve out water molecules at very high flux while blocking air molecules. This would enable higher efficiencies and significant cost savings in cooling technologies.
Architectural Applications (Membrane Technology and Research, Inc., Lawrence Berkeley National Laboratory)	$458,265	Portland, OR	*Dehumidification: Innovative Building-Integrated Ventilation Enthalpy Recovery* This project will develop a new technology that will recycle building exhausted air to partially cool and dehumidify incoming fresh air. This design promises a performance increase of 25-40% compared to conventional air conditioning systems.
Astronautics Corporation of America	$2,889,839	Milwaukee, WI	*Solid State Cooling: An Efficient, Green Compact Cooling System Using Magnetic Refrigeration.* Traditional refrigeration systems use liquid based refrigerants which have global warming potential (GWP) more than 1,000 times that of CO_2. This project proposes to use a solid state cooling technology with GWP of zero based on magnetic refrigeration. The team will construct and test a magnetic refrigeration cooling system that will achieve significant energy efficiency and reduce system operating costs compared to conventional vapor compression systems.
Battelle Memorial Institute, Corporate Operations (Dynamic Solutions, LLC)	$401,654	Columbus, OH	*Vapor Absorption/Adsorption: Cascade Reverse Osmosis and the Absorption Osmosis Cycle* This project will use a new absorption osmosis cycle that uses water as the refrigerant and a salt as the heat absorber. Using reverse osmosis, the approach separates water from a salt solution using an efficient liquid pumping and membrane

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			separation process. This is radically different from traditional cooling technologies that use mechanical compressors, and has the potential to increase the energy efficiency of air conditioning by more than 50%.
Counseling & Consulting Associates (Flometrics, On Target Design)	$400,000	San Diego, CA	*Gas Cycles: Centrifugal Air Cycle Air Conditioning System* The centrifugal air conditioning system uses air as a refrigerant and novel compact system that boosts performance. This technology will use fluids with zero Global Warming Potential and improve energy efficiency in AC systems.
Georgia Tech Research Corporation (Stone Mountain Technologies, Inc., ARS Solutions, LLC)	$2,399,842	Atlanta, GA	*Vapor Absorption/Adsorption: Modular Thermal Hub for Building Cooling, Heating and Water Heating* This project will develop a hub for cooling and heating systems in buildings using microscale passages. It uses fluids with zero Global Warming Potential (GWP) and can achieve from hundreds to tens of thousands of Watts in cooling capacity and a 51% primary energy use reduction.
Infinia Corporation (Heat Transfer Technologies, Enertron, Barry Penswick)	$3,000,617	Kennewick, WA	*Gas Cycles: Stirling Air Conditioner (StAC) for Compact Cooling* This project will develop and demonstrate a prototype Stirling Air Conditioner that combines a Stirling cycle with innovative heat transfer coupling to produce improvements in compact cooling. It will use no greenhouse gases, can achieve high efficiency and can be cost effectively mass-produced.
Material Methods LLC VIT LLC	$399,800	Irvine, CA	*Gas Cycles: Phononic Heat Pump* This project will demonstrate a refrigerator that pumps heat using sound waves. Low cost and high reliability result from high thermal efficiency and mechanical simplicity with no linkages, no exotic materials, and simple construction. The working fluid is environmentally safe and friendly.
Pacific Northwest National Laboratory (Power Partners, Inc., Arkema)	$2,541,952	Richland, WA	*Vapor Absorption/Adsorption: High Efficiency Adsorption Chilling Using Novel Metal Organic Heat Carriers* This project entails the design, assembly and testing of an adsorption chiller that takes advantage of tunable binding energy of metal organic heat carrier (MOHC) sorbents and select refrigerants to achieve high efficiency in commercial heating, ventilation, air conditioning and refrigeration systems.
Sheetak Inc.	$563,303	Austin, TX	*Solid State Cooling: Non-Equilibrium Asymmetric Thermoelectric (NEAT)* This project will develop a high efficiency solid-state refrigeration compressor using a new thermoelectric material system known as Non-Equilibrium Asymmetric Thermoelectric (NEAT). It will use less energy than conventional compressors without using fluids with Global Warming Potential.

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The Pennsylvania State University (ThermoAcoustics Corporation, Heatcraft Worldwide Refrigeration)	$2,988,720	State College, PA	*Gas Cycles: One-ton (3.5 kW thermal) Thermoacoustic Air Conditioner* This project will scale up an existing thermoacoustic chiller system to produce an air conditioning unit that recycles sound for cooling. It will use no exotic materials that increase cost or reciprocating seals that limit service life.
The Regents of the University of California, Los Angeles	$520,547	Los Angeles, CA	*Solid State Cooling: Compact MEMS Electrocaloric Cooling Module* This project will develop a novel solid-state cooling technology to translate a recent scientific discovery of the enhanced electrocaloric effort into commercially viable compact cooling systems that have reduced energy consumption and avoid the use of refrigerants to cool building spaces.
United Technologies Research Center	$2,855,795	East Hartford, CT	*Mechanical Vapor Compression: Water-Based HVAC System* To use water as a refrigerant this project will focus on developing a novel supersonic compressor to achieve a high compression ratio in a single stage. This project will develop a high efficiency air conditioning system to enable a lower cost Vapor Compression (VC) system.
United Technologies Research Center (Pall Corporation, Polymer Science Associates, New Jersey Institute of Technology)	$3,098,765	East Hartford, CT	*Vapor Absorption/Adsorption: Nano-Engineered Porous Hollow Fiber Membrane-Based Conditioning System* With novel integration of a liquid desiccant and a vapor compression cycle this project will develop and demonstrate an air conditioning system optimized for use in warm and humid climates with an efficiency (as measured by primary COP) that is at least 50% greater than conventional air conditioning units.
University of Florida (b2u Solar, Inc., Wolverine Tube, Inc.)	$1,000,000	Gainesville, FL	*Vapor Absorption/Adsorption: A New Generation Solar and Waste Heat Power Absorption Chiller* This project will develop a next generation solar and waste heat powered absorption chiller and refrigeration system that is an order of magnitude smaller than the existing systems with a significantly reduced cost.
University of Maryland (GE Global Research, Pacific Northwest National Laboratory)	$500,001	College Park, MD	*Solid State Cooling: Thermoelastic Cooling* This project will demonstrate the commercial viability of solid state thermoelastic shape memory alloy for space cooling using a 0.01-ton prototype intended to replace conventional vapor compression cooling technology. It will not use fluids with high Global Warming Potential and will have a smaller operational footprint than conventional vapor compression technology.

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University of Notre Dame (Dometic LLC)	$2,817,926	Notre Dame, IN	*Mechanical Vapor Compression: Compact, Efficient Air Conditioning with Ionic Liquid Based Refrigerants* Global warming potential (GWP) of current refrigerants is more than 1000 times the GWP of CO2. This makes CO2 very attractive as refrigerants. However, CO2 based refrigeration systems require approximately 100 times higher pressure than atmospheric pressure for operation. The University of Notre Dame proposes to demonstrate an operating vapor compression HVAC cycle based on CO2- ionic liquids co-fluid system facilitating lower pressure operation, with a much higher efficiency than is currently possible with existing systems.
3) Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS)			
ABB Inc (SuperPower Inc., Brookhaven National Lab)	$4,200,000	Cary, NC	*Superconducting Magnetic Energy Storage (SMES): Superconducting Magnet Energy Storage System with Direct Power Electronics Interface* ABB will lead a team developing an advanced superconducting magnetic energy storage (SMES) device. SMES is a novel technology that stores electricity from the grid in the magnetic field of a coiled wire with near-zero loss of energy. The proposed device will have instantaneous response and nearly infinite cycle life. If the high-risk breakthrough technologies in this project are successfully developed, the result will advance SMES from a high-cost solution for delivering short bursts of energy to a technology that is cost-competitive for delivering megawatt hours of stored electricity.
Beacon Power Corporation (Imlach Consulting Engineering, IONICORP)	$2,250,000	Tyngsboro, MA	*Flywheel: Development of a 100 kWh/100 kW Flywheel Energy Storage Module* Beacon Power will lead a team in developing a next generation flywheel energy-storage technology. In a flywheel system, electricity is stored as kinetic energy in a spinning wheel. The proposed flywheel could store four times more energy than current flywheels at 1/8th the cost. It employs a radically new "flying ring" design that is capable of accepting and delivering energy over 40,000 times during its 20-year lifetime. The proposed technology is ideal for simultaneously addressing both the renewable ramping challenge and other grid-storage applications.
Boeing	$2,264,136	Huntington Beach, CA	*Flywheel: Low-Cost, High-Energy Density Flywheel Storage Grid Demonstration* In this project, Boeing will develop a high-risk materials technology for low-cost, high energy-density flywheel energy-storage. In a flywheel, electricity is stored as kinetic energy in a spinning wheel. While flywheels are currently used for short-

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			duration energy storage, this project will make possible a dramatic increase the energy density of the flywheel for longer-duration applications including renewable energy ramping. To increase energy density, Boeing will develop a new fiber material that allows the flywheel to spin at higher speeds without breaking. The resulting high energy density material will be enable subsequent scaling to utility-size and amenable to factory production at low cost.
CUNY Energy Institute (Rechargeable Battery Corporation)	$3,000,000	New York, NY	*Battery: Low-cost Grid-Scale Electrical Storage using a Flow-Assisted Rechargeable Zinc-Manganese Oxide Battery* In this project, the CUNY Energy Institute, in partnership with Rechargeable Battery Corporation (RBC) and the Ultralife Corporation, will develop a novel battery that radically transforms the chemistry and low-cost materials found in disposable consumer-grade alkaline batteries into a long-lasting, fully-rechargeable energy storage system. While CUNY has already demonstrated some of the basic scientific principles, work in this high-risk project will achieve a rechargeable battery system that lasts for over ten years, costs under $100/kWh, demonstrating potential for use on the electricity grid.
Fluidic Energy, Inc.	$3,000,000	Scottsdale, AZ	*Battery: Enhanced Metal-Air Energy Storage System with Advanced Grid-Interoperable Power Electronics Enabling Scalability and Ultra-Low Cost* Fluidic Energy will develop an advanced multi-functional energy storage (AMES) battery prototype. This is a high-risk technology which, if successful, will enable a highly scalable energy storage system well suited for supporting intermittent renewable resources (solar, wind) on the electric grid. The novel battery chemistry will overcome traditional electricity storage challenges of limited re-chargeability, low power density, and poor efficiency. This low-cost battery technology will be based exclusively on domestically-available, earth abundant active materials. A partnership with Satcon and Chevron Energy Solutions will ensure this project translates rapidly to products supporting renewable generation on the grid.
General Atomics (UC San Diego)	$1,986,308	San Diego, CA	*Flow Battery: GRIDS Soluble Lead Flow Battery Technology* General Atomics and the University of California San Diego will develop a novel flow battery technology, which pumps chemicals through the battery cell when electricity is needed. The proposed flow battery revolutionizes a century-old lead-acid battery technology to achieve low cost, high efficiency and reliability needed for use on the electric power grid. This high-risk technology development program will use novel materials that greatly increase power while resisting the corrosion that limits the cycle life of conventional lead acid

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			batteries. These innovations will result in a battery that can be scaled for grid-scale energy storage, but which costs less and performs far longer than today's technologies.
General Compression	$750,000	Newton, MA	*Compressed Air Energy Storage (CAES): Fuel-Free, Ubiquitous, Compressed Air Energy Storage and Power Conditioning* General Compression will lead a team investigating a novel compressed air energy storage process (GCAES™) that is highly efficient and requires no fossil fuel. In this project, a team of industry and academic researchers will show the potential for a near-isothermal CAES unit, which could result in an energy storage technology with high round-trip electrical efficiency and fast response times. Unlike conventional CAES installations, no fuel will be burned in the expansion stage of the process, dramatically reducing emissions and operating costs. Once successfully developed, the GCAES™ can accelerate the integration of renewable electricity generation, particularly wind, into the grid.
Lawrence Berkeley National Laboratory (DuPont, Bosch, 3M, and Proton Energy)	$1,592,730	Berkeley, CA	*Flow Battery: Hydrogen-Bromine Flow Batteries for Grid-Scale Energy Storage* Lawrence Berkeley National Laboratory and its team of industrial partners (DuPont, Bosch, 3M, and Proton Energy) will develop a novel flow-battery system for grid applications. Flow batteries pump reactive chemicals through the battery cell when electricity is needed; this project's battery will use hydrogen and bromine as its active materials. While this type of flow battery has existed for decades, it has been plagued by high costs, short lifetimes, and safety concerns. In this project, the LBNL team will apply unique technical approaches to address these challenges, and will deliver a proof-of-concept cell that will demonstrate the potential of this chemistry in grid-scale energy storage applications.
Primus Power	$2,000,000	Alameda, CA	*Flow Battery: Low-Cost, High Performance 50 Year Electrodes* Primus Power will develop new durable, inexpensive metal electrodes for flow batteries for energy storage on the electric grid. Electrodes are a key component of flow batteries, which pump reactive chemicals through the battery cell when electricity is needed. Flow batteries are potentially ideal for electric grid storage applications, but are often limited by the high cost and poor durability of the electrodes. In this project, Primus Power will leverage processes developed for other chemical industries to develop novel, low-cost metallic flow battery electrodes. If successful, the result will be a 5X decrease in costs while simultaneously doubling the power density of the energy storage system.

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Proton Energy (Penn State University)	$2,148,719	Wallingford, CT	*Fuel Cell: Transformative Renewable Energy Storage Devices Based on Neutral Water* Proton Energy and Penn State University will develop an advanced energy storage device that incorporates a regenerative fuel cell. Like batteries, fuel cells use chemical reactions to produce electricity. Many fuel cells require expensive precious metals such as platinum to operate. In this novel design, a unique component will be developed that allows the fuel cell to operate without significant use of precious metals. This innovation will dramatically reduce cost, and enable the economical use of this fuel cell system for electricity storage on the grid.
United Technologies Research Center (University of Texas, Clipper Windpower, Pratt & Whitney, Sandia National Labs)	$3,000,000	East Hartford, CT	*Flow Battery: Transformative Electrochemical Flow Storage System (TEFSS)* United Technologies Research Center (UTRC), in partnership with the University of Texas and Sandia National Laboratory, will develop a novel flow battery, a type of battery system that pumps reactive chemicals through the battery cell when electricity is needed. The proposed flow battery uses a unique design to deliver 10X more power than conventional flow batteries. This breakthrough will enable a dramatic reduction in the size and cost of the flow battery. The advanced prototype flow battery developed in this program will provide energy storage at 1/3 the cost of current flow battery systems, and will lay the technical foundation for commercially-available grid-scale energy storage solution.
University of Southern California (Jet Propulsion Laboratory (JPL))	$1,459,324	Los Angeles, CA	*Battery: A Robust and Inexpensive Iron-Air* *Rechargeable Battery for Grid-Scale Energy Storage* Researchers at the University of Southern California and NASA's Jet Propulsion Laboratory will team to develop a high-performance rechargeable battery for large-scale energy storage on the electricity grid. Iron air batteries have the potential to store large amounts of energy inexpensively since they rely on extremely low-cost materials: iron, which costs less than $.20/pound, and oxygen which is free in ambient air. Although, existing iron-air batteries have suffered from low energy efficiency and poor cycle life, in this high-risk technology development project, novel approaches will be tested, including new materials and structures to increase battery efficiency and cycle-life. This project will develop an iron-air proof of concept battery, the first step in the commercialization of this promising, low-cost battery chemistry.
TOTAL FUNDING	**$92,356,887**		