

ARPA-E Project Selections

April 29, 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)	Project Description
1) Electrofuels			
University of Massachusetts Amherst (University of California San Diego, Genomatica)	\$1,000,000	Amherst, MA	Electrofuels via Direct Electron Transfer from Electrodes to Microbes <i>Reducing equivalent: Electrons; Organism: N/A; Product: Butanol</i> This project seeks to enhance the productivity of microbial electrosynthesis, a technology in which microorganisms directly use electric current (such as from solar PV) to convert water and carbon dioxide into fuels and other organic chemicals, potentially at much higher efficiencies than traditional photosynthesis and with less production of waste, lower water usage, and no need for arable land. The short-term goal of the project is to optimize microorganisms already capable of microbial electrosynthesis for the production of butanol, which can be excreted from the cells to facilitate fuel processing.
Pennsylvania State University (University of Kentucky)	\$1,500,000	University Park, PA	Development of Rhodobacter as a Versatile Microbial Platform for Fuels Production <i>Reducing equivalent: Electrically-derived Hydrogen; Organism: Rhodobacter; Production: Hydrocarbons</i> The project will produce an organism capable of using electricity to ultimately produce gasoline from carbon dioxide. The team will engineer hydrocarbon biosynthesis genes from an oil producing algae into a hydrogen-consuming bacteria for efficient biofuel production. The project also includes innovative concepts for engineering microbial fuel cells and bioreactor systems.
The Ohio State University (Battelle Memorial Institute)	\$3,977,349	Columbus, OH	Bioconversion of Carbon Dioxide to Biofuels by Facultatively Autotrophic Hydrogen Bacteria <i>Reducing equivalent: Hydrogen; Organism: Hydrogen bacteria; Product: Butanol</i> This is a technology for the efficient bioconversion of carbon dioxide into an infrastructure-compatible liquid biofuel, butanol, without using photosynthesis. The project includes genetic modifications of bacteria that metabolize carbon dioxide, oxygen, and hydrogen to produce butanol; development of an industrially scalable bioreactor system; and a novel approach to recovery of butanol from the bioreactor. The team anticipates at least a twofold productivity improvement over current levels and a cost that can be competitive with gasoline. The project also includes a proprietary process to convert waste biomass into carbon dioxide and hydrogen to feed the bioreactor, allowing butanol production from waste feedstocks.
Massachusetts Institute of Technology (Michigan State University)	\$1,771,404	Cambridge, MA	Engineering <i>Ralstonia eutropha</i> for Production of Isobutanol (IBT) Motor Fuel from Carbon Dioxide, Hydrogen & Oxygen <i>Reducing equivalent: Hydrogen; Organism: Ralstonia eutropha; Product: Butanol</i> This project relies on microbes that use hydrogen to convert carbon dioxide into liquid transportation fuels. The project will develop a system using <i>Ralstonia eutropha</i> to redirect carbon flux to butanol production in a novel bioreactor system with increased performance.

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Ginkgo BioWorks (University of California Berkeley, University of Washington)	\$6,000,000	Boston, MA	<p>Engineering E. coli as an electrofuels chassis for isooctane production <i>Reducing equivalent: Electrons; Organism: E. coli; Product: Isooctane</i></p> <p>This project seeks to develop an "electrofuels chassis" by using engineered <i>E. coli</i> to convert carbon dioxide and electrical energy into short, branched-chain alkanes—molecules which cannot be produced using other known biosynthetic pathways. The target liquid fuel is isooctane, which fits well into the existing transportation fuel system in the United States.</p>
Harvard Medical School-Wyss Institute	\$4,194,125	Boston, MA	<p>Engineering a Bacterial Reverse Fuel Cell <i>Reducing equivalent: Electrons; Organism: N/A; Product: Octanol</i></p> <p>The goal of the proposed research is to engineer a bacterium to absorb electrical current as an input and convert this energy into chemical energy in the form of a biofuel. The bacteria will be engineered to accept electrons in the form of current, to fix carbon dioxide, and to produce a biofuel, specifically octanol. Finally, a device that combines features of an electrochemical cell and a microbial fermenter will be developed.</p>
Massachusetts Institute of Technology (Harvard University, University of Delaware)	\$3,195,563	Cambridge, MA	<p>Bioprocess and Microbe Engineering for Total Carbon Utilization in Biofuel Production <i>Reducing equivalent: Hydrogen (or Electrons); Organism: anaerobe and aerobe; Product: Oil for biodiesel</i></p> <p>This project will develop a process to combine an anaerobic carbon dioxide-fixing microbe in one stage with an aerobic oil-producing microbe in a second stage. From hydrogen and carbon dioxide, the anaerobic organism would produce an organic compound, such as acetate, that could be used by the aerobic microbe for growth and oil production at close-to-theoretical yields. The net effect would be the production of oil for biodiesel from carbon dioxide and hydrogen or electricity. The aerobic microbe has been engineered at MIT and is capable of converting a variety of organic compounds into oil, from which biodiesel may be produced. The project aims to dramatically increase volumetric productivity (for acetate production) using targeted metabolic engineering and integrated bioprocess development.</p>
North Carolina State University (University of Georgia)	\$2,729,976	Raleigh, NC	<p>Hydrogen-Dependent Conversion of Carbon Dioxide To Liquid Electrofuels By Extremely Thermophilic Archaea <i>Reducing equivalent: Hydrogen; Organism: Archaea; Product: Precursors to ethanol and butanol</i></p> <p>This project seeks to combine the enzymes from a novel carbon fixation cycle in an extremophilic microbe termed an archaeon that grows optimally near 75°C with the hydrogen utilizing hydrogenase enzyme from another extremophilic archaeon to construct a hybrid enzymatic pathway. The novel pathway will use hydrogen gas to convert carbon dioxide into C-2 and C-4 compounds that will serve as precursors to biofuels, such as butanol.</p>

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<p>OPX Biotechnologies Inc.</p> <p>(National Renewable Energy Laboratory, Johnson Matthey Catalysts Inc.)</p>	\$6,000,000	Boulder, CO	<p><i>Novel Biological Conversion of Hydrogen and Carbon Dioxide Directly into Biodiesel</i> <i>Reducing equivalent: Hydrogen; Organism: Cupriavidus necator; Product: Biodiesel</i></p> <p>This project will develop and optimize a novel, engineered microorganism that produces a biodiesel-equivalent fuel from renewable hydrogen and carbon dioxide, at costs of less than \$2.50 per gallon. Water will be the primary byproduct. The project will draw on OPXBIO's proprietary genomics technology and NREL's improved microorganisms for hydrogen utilization and carbon fixation for rapid metabolic engineering. Johnson Matthey will investigate the catalytic conversion of this microbial biodiesel into additional fuel molecules, most importantly jet fuel.</p>
<p>University of California Los Angeles</p> <p>(Easel Biotechnologies LLC, University of California Davis)</p>	\$4,000,000	Los Angeles, CA	<p><i>Electro-Autotrophic Synthesis of Higher Alcohols</i> <i>Reducing equivalent: Electrons; Organism: N/A; Product: Higher alcohols</i></p> <p>This project will develop microorganisms using synthetic biology and metabolic engineering techniques to use electricity instead of sunlight for biological carbon dioxide fixation and fuel synthesis. This process will repurpose carbon dioxide for use as a liquid fuel that can be readily used as a high octane gasoline substitute.</p>
<p>Medical University of South Carolina</p> <p>(Clemson University, University of South Carolina)</p>	\$2,342,602	Charleston, SC	<p><i>Electroalcoholgenesis: Bioelectrochemical Reduction of CO₂ to Butanol</i> <i>Reducing equivalent: Electrons; Organism: N/A; Product: Butanol or ethanol</i></p> <p>This project will develop a microbially catalyzed electrolysis cell that uses electricity (e.g. from solar PV) to convert carbon dioxide into liquid alcohol fuels. The process will produce butanol and will also be able to produce ethanol. The research team has a strong connection with Microbial Fuel Cell Technologies, LLC in this area of research.</p>
<p>Columbia University</p>	\$543,394	New York, NY	<p><i>Biofuels from CO₂ using Ammonia-Oxidizing Bacteria in a Reverse Microbial Fuel Cell</i> <i>Reducing equivalent: Electrons (via Ammonia); Organism: N. europaea; Product: Butanol</i></p> <p>This project will use the chemolithoautotrophic ammonia-oxidizing bacteria <i>N. europaea</i> to produce isobutanol from carbon dioxide. The team will genetically engineer the microorganism to demonstrate that they can efficiently reduce ammonia that can be generated electrochemically from nitrite, or supplied from waste water streams, to fix carbon dioxide.</p>
<p>Lawrence Berkeley National Laboratory</p> <p>(University of California Berkeley, Logos Technologies Inc.)</p>	\$3,948,493	Berkeley, CA	<p><i>Development of an Integrated Microbial-ElectroCatalytic (MEC) System for Liquid Biofuel Production from CO₂</i> <i>Reducing equivalent: Electrons (via Hydrogen); Organism: Ralstonia eutropha; Product: Butanol and alkenes</i></p> <p>This project will develop a novel, combined microbial and electrochemical catalytic system to convert hydrogen and carbon dioxide into energy-dense biofuels. A common soil bacterium, <i>Ralstonia eutropha</i>, will be genetically modified to produce biofuels including butanol and alkenes, which can serve as replacements for petroleum-derived fuels. A novel metal complex for electrolysis of water will be used to generate the hydrogen at high rates. The project also will develop a chemical method to transform butanol into jet fuel.</p>

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2) Batteries for Electrical Energy Storage in Transportation (“BEEST”)			
Sion Power Corporation (BASF, Lawrence Berkeley National Laboratory, Pacific Northwest National Laboratory)	\$5,000,000	Tucson, AZ	<p>Li-S Battery: <i>Development of High Energy Li-S Cells for Electric Vehicles</i></p> <p>Sion Power Corporation, a Brookhaven National Laboratory spin-out company, will develop an ultra-high energy Lithium-Sulfur battery able to power electric vehicles more than 300 miles between charges, with an energy density of 500Wh/kg that is 3x that of current Li-ion batteries. While the high energy potential of Lithium-Sulfur is well known, Sion Power's proprietary strategy, focusing on a manufacturable approach to lithium anode protection and employing six different physical barrier layers, highly differentiates Sion's approach from all other Lithium-Sulfur efforts. These strategies directly address cycle life and safety while also allowing higher energies. If successful, this project will clearly assert U.S. technology and commercialization leadership in ultra-high energy batteries for electrified vehicles.</p>
ReVolt Technology LLC	\$5,000,335	Portland, OR	<p>Zn-Air Battery: <i>Zinc Flow Air Battery (ZFAB), the Next Generation Energy Storage for Transportation</i></p> <p>ReVolt Technology will develop a novel large format high-energy zinc-air flow battery for long all-electric range Plug-In and All Electric vehicles. This novel high energy battery concept is based upon a closed loop system in which the zinc (anode), suspended as slurry in a storage tank, is transported through reaction tubes (cathode) to facilitate the discharge and recharge of the battery. ReVolt's fundamental breakthroughs in air electrodes enable a new class of high-energy rechargeable battery systems that combines key innovations from the fields of fuel cells and batteries.</p>
PolyPlus Battery Company (Corning Inc.)	\$4,996,311	Berkeley, CA	<p>Li-Air Battery: <i>Development Of Ultra-high Specific Energy Rechargeable Lithium/Air Batteries Based On Protected Lithium Metal Electrodes</i></p> <p>PolyPlus Battery Company and Corning Incorporated will work together to achieve transformational improvements in rechargeable Li-Air battery technology. PolyPlus's lithium-air batteries based on proprietary protected lithium electrodes and Corning's specialization in glass, ceramics, and record of moving technology from laboratory to manufacturing have great promise for advancing Li-Air technology, which holds promise to rival the energy density of gasoline. With a clear path to commercialization this technology hopes to revolutionize Li-Air batteries for electric vehicle applications.</p>
Pellion Technologies, Inc. (Massachusetts Institute of Technology, Bar-Ilan University)	\$3,204,080	Menlo Park, CA	<p>Mg-Ion Battery: <i>Low-Cost Rechargeable Magnesium Ion Batteries with High Energy Density</i></p> <p>Pellion Technologies Inc., an MIT spin-out company, will develop inexpensive high-energy-density rechargeable magnesium-ion batteries with the potential to disrupt current energy storage technologies for electric and hybrid-electric vehicles. To develop a game-changing magnesium-ion battery, Pellion will leverage high throughput computational materials design coupled with accelerated materials synthesis and electrolyte optimization to identify new high-energy-density magnesium cathode materials and compatible electrolyte chemistries. If successful, this project will develop the first commercial magnesium-ion battery and will establish U.S. technology leadership in this exciting new high energy battery chemistry for electrified vehicle applications.</p>

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Applied Materials, Inc. (A123 Systems, Inc., Lawrence Berkeley National Laboratory)	\$4,373,990	Santa Clara, CA	<p>Advanced Li-Ion Battery Manufacturing: Novel High Energy Density Lithium-Ion Cell Designs via Innovative Manufacturing Process Modules for Cathode and Integrated Separator</p> <p>Applied Materials Inc. will lead an effort to develop ultra-high energy low cost lithium-ion batteries enabled by disruptive new manufacturing processes. This novel approach will focus on developing a high energy density porosity-graded cathode on 3D current collectors, an integrated separator, and a suite of modular manufacturing processes that have the potential to transform lithium-ion battery manufacturing technology. These high energy cathodes will be incorporated with new high capacity anodes to demonstrate prototype manufacturing of high energy lithium-ion cells with energy density greater than 400 Wh/kg and extremely low cost. If successful, this project will establish U.S. leadership in the manufacturing of high energy, low cost advanced lithium-ion battery technology for electric vehicles.</p>
Massachusetts Institute of Technology (A123 Systems, Inc., Rutgers University)	\$4,973,724	Cambridge, MA	<p>Novel Battery: Semi-Solid Rechargeable Power Sources: Flexible, High Performance Storage for Vehicles at Ultra-Low Cost (<\$0.10/Wh)</p> <p>Researchers at the Massachusetts Institute of Technology, in collaboration with A123 Systems and Rutgers University, will seek to develop a revolutionary new electrical energy storage concept for transportation that combines the best attributes of rechargeable batteries and fuel cells. This technology incorporates semi-solid high energy density rechargeable, renewable and recyclable electrochemical fuel in a flow system that decouples power from stored energy. Early stage results suggest that high energy density and system costs less than \$100/kWh can be obtained, which would enable rapid widespread adoption of electric vehicles.</p>
Planar Energy Devices, Inc. (National Renewable Energy Laboratory, UC San Diego, University of Central Florida, University of Colorado - Boulder, University of Florida, University of South Florida)	\$4,025,373	Orlando, FL	<p>Solid State Lithium Battery: Solid State All Inorganic Rechargeable Lithium Batteries</p> <p>Planar Energy Devices, Inc, an Orlando, FL based early stage battery technology company, will seek to develop an ultra high energy, long cycle life all solid-state lithium battery that can manufactured using low cost non-vacuum fabrication techniques, targeting energy densities of 400Wh/kg and 1,080Wh/liter; system costs of \$200/kWh, and cycle life of 5,000, Planar Energy Devices will demonstrate pilot manufacturing of these disruptive new batteries using a low cost roll-to-roll process in ambient environment, all inorganic materials, and solid state electrolytes whose ionic conductivity is similar to existing liquid electrolytes. If successful, this project will establish the U.S. as a leader in advanced high energy battery technology and low cost manufacturing processes in batteries for electrified vehicles.</p>
Stanford University (Honda, Applied Materials, Inc.)	\$1,000,000	Stanford, CA	<p>Novel Battery: The All-Electron Battery: a quantum leap forward in energy storage</p> <p>In this project, researchers Stanford University will seek to develop an "All-Electron Battery", a completely new class of electrical energy storage devices for electric vehicles that has the potential to provide ultra-high energy and power densities, while enabling extremely high cycle life. The All-Electron Battery stores energy by moving electrons, rather than ions, and uses electron/hole redox instead of capacitive polarization of a double-layer. This technology uses a novel architecture that has potential for very high energy density because it decouples the two functions of capacitors: charge separation and breakdown strength. If successful, this project will develop a completely new paradigm in energy storage for electrified vehicles that could revolutionize the electric vehicle industry and establish U.S. leadership in advanced energy storage technology for electric vehicles.</p>

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Recapping, Inc. (Penn State University)	\$1,000,000	University Park, PA Menlo Park, CA	<p>Capacitive Storage: High Energy Density Capacitor</p> <p>Recapping Inc. and researchers at Pennsylvania State University will seek to develop a novel energy storage device based on a 3D nanocomposite structure with functional oxides that provide a very high effective capacitance. The basic fabrication of the dielectric materials and devices will utilize traditional multilayer ceramic fabrication methods that will provide a cost effective alternative to battery solutions, with added benefits of exploiting mechanisms that could maintain higher cycling and possibly deliver charge with high power density. This technology hopes to create a cyclable and economically competitive energy storage device that will catalyze new, related cleantech industries and contribute to the reduction of greenhouse gases and oil imports.</p>
Missouri University of Science & Technology (Brookhaven National Laboratory, MaxPower Inc., NanoLab Inc.)	\$999,997	Rolla, MO	<p>Li-Air Battery: High Performance Cathodes for Li-Air Battery</p> <p>Researchers at the Missouri University of Science and Technology will lead a multi-disciplinary team to develop a disruptive new high energy air cathode to enable the successful development of ultra-high energy Lithium-Air batteries. Lithium-Air batteries have extremely high theoretical energy densities (5,000-12,000 Wh/kg) approaching those of gasoline due to the use of a high capacity lithium anode and oxygen from the air. However, existing Lithium-Air technologies have exhibited very low power, round trip efficiency, and cycle life due to severe performance limitations at the air cathode. In this project, researchers will seek to dramatically improve Lithium-Air air cathode performance through the development of a new hierarchical electrode structure to enhance oxygen diffusion from the air and novel high performance bifunctional oxygen reduction and evolution catalysts. If successful, this project will dramatically improve the state of the art in ultra high energy Lithium-Air batteries and will re-establish U.S. technology leadership in this potentially disruptive battery technology for long range all-electric vehicles.</p>
3) Innovative Materials & Processes for Advanced Carbon Capture Technologies (“IMPACCT”)			
Codexis Inc. (Nexant Inc.)	\$4,657,045	Redwood City, CA	<p>Solvents / Catalysts: Low-Cost Biocatalyst for Acceleration of Energy Efficient CO2 Capture Solvents</p> <p>Codexis proposes to develop low-cost enzymes for carbon capture from coal-fired power plants. Carbonic anhydrases (CAs), enzymes which catalyze CO2 hydration, can enable the use of otherwise slow capture solvents with dramatically lower energy losses than current technology. Existing CAs are prohibitively expensive due to their low activity and short lifetime and high manufacturing (fermentation) costs. Codexis will apply its directed evolution technology to develop lower-cost thermophile-derived CAs with improved activity and stability and its strain evolution technology to develop a low-cost manufacturing process for the enzyme.</p>
Texas A&M	\$1,019,874	College Station, TX	<p>Sorbents: Stimuli-responsive Metal-Organic Frameworks for Energy Efficient Post-Combustion Carbon Dioxide Capture</p> <p>Texas A&M will develop innovative metal organic framework (MOF) based molecular sieves whose adsorption and desorption properties can be finely tuned by controlling their mesh size. This will enable more energy efficient carbon dioxide capture and reduce the cost of CO2 capture by enhancing CO2/N2 selectivity at high CO2 loadings and by greatly lowering the cost of regeneration. The team will demonstrate a process that can capture 90% of the CO2 in flue gas with substantially reduced parasitic power demand.</p>

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Massachusetts Institute of Technology (Siemens)	\$1,000,000	Cambridge, MA	<p>Sorbents: <i>Electrochemically Mediated Separation for Carbon Capture and Mitigation</i></p> <p>The MIT-led team will develop electrochemically mediated separation (ECMS) processes for post-combustion CO₂ capture at coal-fired power plants. Anticipated benefits include greatly increased energy efficiency for carbon dioxide capture, easier retrofitting of existing coal-fired power plants, and simpler integration with new facilities. The project will involve molecular modeling and experimental optimization of carrier structure, fabrication and evaluation of prototype separation units.</p>
University of Kentucky-Center for Applied Energy Research	\$1,955,078	Lexington, KY	<p>Membranes / Solvents: <i>A Solvent/Membrane Hybrid Post-combustion CO₂ Capture Process for Existing Coal-Fired Power Plants</i></p> <p>The University of Kentucky-led team will develop a hybrid absorption solvent/catalytic membrane post-combustion CO₂ capture process for existing coal-fired power plants. The membrane acts as a catalytic separator, coupling nanofiltration separation and catalysis functions to produce a concentrated permeate that lowers regeneration costs. The solvents of interest include aqueous ammonium and some typical alkyl amines (e.g., MEA). This catalytic membrane reactor could greatly reduce the energy penalty for CO₂ capture, and the membrane unit could be conveniently integrated into the typical carbon capture process for fossil fuel-fired power plants.</p>
GE Global Research Center (GE Energy, Univ. of Pittsburgh)	\$3,017,511	Niskayuna, NY	<p>Phase Change: <i>CO₂ Capture Process Using Phase-Changing Absorbents</i></p> <p>This GE-led team will develop a novel cost-efficient CO₂ capture process that uses a liquid absorbent which, upon contact with CO₂, changes into a solid powder. The solid can be separated and the CO₂ can be released by heating, after which the absorbent returns to its liquid form. Because the absorbent solid contains a high percentage of CO₂, the energy efficiency of the process is improved over current technology, and compression and capital costs are reduced. The goal is to achieve <10% parasitic power load at 90% CO₂ capture and <\$25/ton CO₂ capture cost. In addition, the approach offers a smaller footprint and would be retrofittable into existing plants.</p>
Lawrence Livermore National Laboratory (University of Illinois Urbana-Champaign, Babcock & Wilcox)	\$3,665,000	Livermore, CA	<p>Solvents / Catalysts: <i>Catalytic Improvement of Solvent Capture Systems</i></p> <p>Synthetic small-molecule catalysts can greatly speed the absorption of CO₂ into liquid solvents and can enable solvents that bind CO₂ less tightly. This project combines scientific experience in creating synthetic small-molecule catalysts (LLNL, UIUC) with industrial experience to make them operationally useful (B&W) in both existing and new CO₂-capture systems. The team will use computational design techniques to develop small molecule catalysts that mimic enzyme functions; essential structural features will be extracted from enzyme data. Another key technical goal is protecting catalysts from degradation in industrial environments.</p>

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Lawrence Berkeley National Laboratory (Wildcat Discovery Technologies, Electric Power Research Institute)	\$3,663,696	Berkeley, CA	<p>Sorbents: <i>High throughput tools to screen new Metal Organic Framework (MOF) materials</i></p> <p>The team lead by LBL will develop high throughput characterization tools to rapidly screen new Metal Organic Framework (MOF) materials. Specific innovations in NMR tools for rapid porosity measurements and in gas sorption measurements will allow rapid evaluation of new synthetic compounds aimed at improvements in CO₂ selectivity and robustness to flue gas environments. Wildcat Technologies is developing the innovative adsorption measurement tool, and EPRI will be doing process modeling and evaluation based on the new material properties.</p>
Georgia Institute of Technology	\$1,000,000	Atlanta, GA	<p>Membranes: <i>Metal Organic Frameworks in hollow fiber membranes for CO₂ capture</i></p> <p>This Georgia Tech proposal will incorporate metal organic frameworks - new compounds that show great promise in carbon capture - into hollow fiber membranes for improved CO₂ selectivity. The use of hollow fiber membranes allows high surface area, and the selective incorporation of MOFs into the polymer matrix will improve throughput and selectivity, helping to reduce capture costs.</p>
Notre Dame University (Mid-Atlantic Technology, Research, & Innovation Center)	\$2,559,563	South Bend, IN	<p>Phase Change: <i>Phase-changing ionic liquids for CO₂ capture</i></p> <p>A recent discovery by Notre Dame has identified a class of ionic liquid materials which undergo a phase transition from solid phase to liquid when reacting with CO₂. A detailed synthetic study of these new compounds will aim to identify materials best suited for carbon capture applications. Lower heats of regeneration are required with these materials, since the heat of fusion during the phase change reduces the amount of energy input to release the CO₂ that is captured.</p>
ATK (ACENT Laboratories)	\$1,000,000	Ronkonkoma, NY	<p>Phase Change: <i>Supersonic nozzles for CO₂ precipitation as a solid</i></p> <p>ATK and ACENT will investigate the use of supersonic nozzles for rapid expansion and cooling of flue gas that will precipitate out the CO₂ for collection and capture. This technology, based on rocket nozzle and wind tunnel applications is a novel application to carbon capture, and offers the potential for a simplified integration with existing power plants.</p>
Columbia University (Sandia National Laboratory, REI)	\$1,014,707	New York NY	<p>Solvents / Catalysts: <i>Accelerated weathering for carbon sequestration</i></p> <p>CO₂ reacts with minerals such as Magnesium silicates in nature over a long period of time, but results in a stable precipitate in an energetically favorable reaction. The ability to accelerate this reaction could provide an alternative to carbon sequestration, and is the focus of this work. This work will investigate catalytic enhancements to the leaching of minerals from mine waste to improve the rates for carbonate formation from the mineral salts.</p>
University of Colorado at Boulder (Los Alamos National Laboratory, Electric Power Research Institute)	\$3,144,646	Boulder, CO	<p>Membranes: <i>Gelled ionic liquid membranes</i></p> <p>UC Boulder will be developing novel gelled ionic liquid membranes, which provide mechanical rigidity into what is normally a liquid solvent, allowing extremely thin membranes to be fabricated. Since the membrane permeance increases as the membranes become thinner, higher fluxes of CO₂ can be selectively passed through the membrane, reducing the cost and size of membrane treatment for flue gas.</p>

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Oak Ridge National Laboratory (Georgia Institute of Technology)	\$987,547	Oak Ridge, TN	Sorbents: <i>Hollow fiber membranes with ionic liquids for CO2 capture</i> The team from Oak Ridge and Georgia Tech are using hollow fiber membranes to provide a high surface area support for ionic liquids to capture and release CO2. In order to provide rapid adsorption and desorption of the CO2, water or steam are passed through the fibers which rapidly heat or cool the sorbent. These fast thermal cycles can reduce the capital costs by minimizing the equipment needed for CO2 capture
Research Triangle Institute (BASF)	\$2,000,000	Research Triangle Park, NC	Solvents: <i>CO2-binding organic liquids</i> RTI and BASF are teaming to explore a new class of materials known as CO2 binding organic liquids. These co-solvents form a miscible mixture that becomes an ionic liquid with high CO2 uptake upon reaction with flue gas. By using solvents that are not compatible with water, low energy separation techniques may be used to remove the water, which would normally require an energy intensive distillation process.
TOTAL FUNDING	\$106,461,383		