U.S. DEPARTMENT OF
ENERGY

Advanced Research Projects Agency – Energy Annual Report for FY2013

Report to Congress
APRIL 2014

United States Department of Energy
Washington, DC 20585

Message from the Acting Director

The Advanced Research Projects Agency-Energy (ARPA-E) catalyzes and accelerates energy technologies that will enhance the economic and energy security of the United States through the development of transformational technologies that reduce America's dependence on energy imports; reduce energy related emissions; improve energy efficiency across all sectors of the economy; and ensure the United States maintains a technological lead in developing and deploying advanced energy technologies. ARPA-E advances high-potential, high-impact energy technologies that are too early for private sector investment and could lead to entirely new ways to generate, store, and use energy. It is important to note that the Agency's missions are not mutually exclusive. These technologies allow for the development of safe and responsible domestic energy and promote the administration's goal of U.S. global leadership in the clean energy economy.

Pursuant to statutory requirements, this report is being provided to the following Members of Congress:

- **The Honorable Fred Upton**
  Chairman, House Committee on Energy and Commerce
- **The Honorable Henry Waxman**
  Ranking Member, House Committee on Energy and Commerce
- **The Honorable Lamar Smith**
  Chairman, House Committee on Science, Space and Technology
- **The Honorable Eddie Bernice Johnson**
  Ranking Member, House Committee on Science, Space and Technology
- **The Honorable Cynthia Lummis**
  Chairwoman, Subcommittee on Energy
  House Committee on Science, Space and Technology
- **The Honorable Eric Swalwell**
  Ranking Member, Subcommittee on Energy
  House Committee on Science, Space & Technology
- **The Honorable Hal Rogers**
  Chairman, House Committee on Appropriations
- **The Honorable Nita Lowey**
  Ranking Member, House Committee on Appropriations
- **The Honorable Mike Simpson**
  Chairman, Subcommittee on Energy and Water Development
  House Committee on Appropriations

- **The Honorable Marcy Kaptur**
  Ranking Member, Subcommittee on Energy and Water Development
  House Committee on Appropriations

- **The Honorable Mary Landrieu**
  Chairwoman, Senate Committee on Energy and Natural Resources

- **The Honorable Lisa Murkowski**
  Ranking Member, Senate Committee on Energy and Natural Resources

- **The Honorable Al Franken**
  Chairman, Subcommittee on Energy
  Senate Committee on Energy and Natural Resources

- **The Honorable James E. Risch**
  Ranking Member, Subcommittee on Energy
  Senate Committee on Energy and Natural Resources

- **The Honorable Barbara Mikulski**
  Chairwoman, Senate Committee on Appropriations

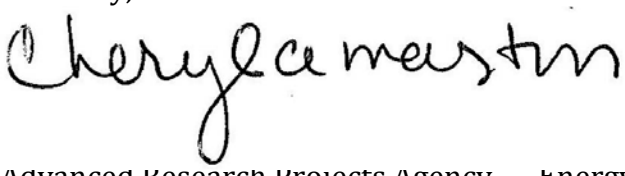
- **The Honorable Richard Shelby**
  Ranking Member, Senate Committee on Appropriations

- **The Honorable Dianne Feinstein**
  Chairman, Senate Subcommittee on Energy and Water Development
  Senate Committee on Appropriations

- **The Honorable Lamar Alexander**
  Ranking Member, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations

If you have any questions or need additional information, please contact me or Mr. Brad Crowell, Assistant Secretary for Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerely,



Advanced Research Projects Agency — Energy (ARPA-E)

Executive Summary

This report presents a summary of the activities of the Advanced Research Projects Agency-Energy (ARPA-E) during Fiscal Year 2013 (FY2013).

In FY2013, ARPA-E issued funding solicitations and selected projects for three new programs covering a broad array of energy technologies, including: $36 million to develop transformational energy storage technologies for electric vehicles; $32 million to develop cost-effective, energy-efficient manufacturing techniques for processing and recycling lightweight metals; and $34 million to develop transformational biological technologies to convert natural gas to liquids for transportation fuels.

ARPA-E announced two additional funding opportunities in FY2013 with project selections that were ultimately announced in FY2014. These programs include $27 million to develop next-generation power switching devices that improve energy efficiency in a wide range of applications – including new lighting technologies, computer power supplies, industrial motor drives, and automobiles – and $30 million to advance solar energy beyond current photovoltaic (PV) and concentrated solar power (CSP) technologies. Altogether, technologies funded through these five programs have the potential to transform the way we generate, use, and store energy. In September 2013, ARPA-E also began utilizing *Innovative Development in Energy-Related Applied Science* (OPEN IDEAS), a rolling open solicitation that will allow ARPA-E to quickly support innovative applied energy research that has the potential to lead to new focused programs.

In addition to these new programs, ARPA-E hosted the fourth annual Energy Innovation Summit from February 25-27, 2013. The Summit brought together leaders from academia, government, and business to discuss the foremost energy issues, showcase the latest technology innovations, and cultivate relationships to help advance cutting-edge technologies to market. The event drew over 2,200 attendees from 49 states and 26 countries and featured over 150 speakers and keynote addresses. At the Summit, ARPA-E recognized several preliminary indicators of likely project success, including that 17 projects had attracted over $450 million in private sector follow-on funding after ARPA-E's initial investment of approximately $70 million.

Finally, ARPA-E continued to focus on providing awardees with practical training and critical business information as part of the Agency's Technology-to-Market program. This support equips projects with a clear understanding of market needs to guide technical development and help projects succeed.

ARPA-E ANNUAL REPORT FOR FISCAL YEAR 2013

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I. Legislative Language

This report responds to a requirement in the America COMPETES Act (P.L. 110-69, sec. 5012(g)(1)(2007)) that:

> *"…the Director shall provide to the relevant authorizing and appropriations committees of Congress a report describing projects supported by ARPA-E during the previous fiscal year."*

The projects referenced throughout this report have been chosen on a highly selective, competitive basis. ARPA-E thoroughly reviews all applications and technologies to ensure that investments are made in areas not currently undertaken by industry.

II. Fiscal Year 2013 Appropriation

ARPA-E was appropriated $265 million for FY2013, pursuant to the Consolidated and Further Continuing Appropriations Act, 2013 (P.L. 113-6). The Agency ultimately received $250 million in FY2013 as prescribed by the Budget Control Act of 2011 (P.L. 112-25).

III. Funding Opportunity Announcements (FOAs)

In FY2013, ARPA-E announced five funding opportunity announcements (FOA) to advance innovative energy technologies in specific program areas. Project selections for three of these FOAs were announced during FY2013, while selections for the remaining two programs were announced in FY2014. The five "focused" programs provide a unique bridge from basic science to early stage technology. These programs draw from the latest scientific discoveries and envision a viable path to commercial implementation through firm grounding in the economic realities and changing dynamics of the marketplace.

On August 21, 2013, ARPA-E announced that 22 projects were selected to receive $36 million through **RANGE** (*Robust Affordable Next Generation Energy Storage Systems*). On September 19, 2013, the Agency announced a total of $66 million for two programs: **METALS** (*Modern Electro/Thermochemical Advancements for Light-metal Systems*), which provided $32 million across 18 projects, and **REMOTE** (*Reducing Emissions using Methanotrophic Organisms for Transportation Energy*), which provided $34 million across 15 projects.

Later in FY2013, ARPA-E issued solicitations for two programs which did not announce project selections until FY2014: **SWITCHES** (*Strategies for Wide Bandgap, Inexpensive*

Transistors for Controlling High Efficiency Systems), which provided $27 million dollars to 14 projects on October 21, 2013, and **FOCUS** (*Full-Spectrum Optimized Conversion and Utilization of Sunlight*), which provided $30 million to 12 projects on February 6, 2014.

In September 2013, ARPA-E also began utilizing **OPEN IDEAS** (*Innovative Development in Energy-Related Applied Science*), a rolling open solicitation that will allow ARPA-E to quickly support innovative applied energy research that has the potential to lead to new focused programs.

As of February 2014, ARPA-E has invested over $900 million across 362 projects through 18 focused programs and two open funding solicitations (OPEN 2009 and OPEN 2012).

The details of the focused programs funded by the FY2013 FOAs as announced are:

- **RANGE: *Robust Affordable Next Generation Energy Storage Systems* ($36,000,000)**
    - The RANGE program seeks to accelerate the widespread adoption of electric vehicles by developing transformational electrochemical energy storage technologies that will enhance vehicle safety, maximize the overall energy stored in a vehicle, and minimize manufacturing costs. RANGE focuses on four specific areas:
        1. Aqueous batteries constructed using water to improve safety and reduce costs,
        2. Non-aqueous batteries that incorporate inherent protection mechanisms that ensure no harm to vehicle occupants in the event of a collision or fire,
        3. Solid-state batteries that use no liquids or pastes in their construction, and
        4. Multifunctional batteries that contribute to both vehicle structure and energy storage functions.
    - **Example RANGE Project: University of California, San Diego – "*Multifunctional Battery Systems for Electric Vehicles*" – San Diego, CA ($3,498,067).** The University of California, San Diego (UCSD) will develop a new battery that can be built into a vehicle frame. Unlike current electric vehicle batteries that remain separate from the vehicle body, the new batteries and redesigned auto frame will become a part of the vehicle's support structure. This integration will lower cost and vehicle weight, while increasing driving range.
    - **Example RANGE Project: Solid Power – "*All Solid-State Lithium-Ion Battery*" – Louisville, CO ($3,459,250).** Solid Power will develop a new low-cost, all-solid-state battery for electric vehicles with improved energy density and safety than conventional lithium-ion batteries. Solid Power's liquid- free cells use non-flammable and non-volatile materials that result in greater stability in the event of a collision or elevated temperature.

Additionally, the use of low-cost, abundant materials in Solid Power's battery construction will result in lower material costs.

- **METALS:** ***Modern Electro/Thermochemical Advancements for Light-metal Systems*** **($32,000,000)**
    - METALS aims to find cost-effective and energy-efficient manufacturing techniques to process and recycle metals for lightweight vehicles and aircraft. Processing light metals such as aluminum, titanium, and magnesium more efficiently would enable the manufacture of vehicles and aircraft that can save fuel and reduce carbon emissions without compromising performance or safety.
    - **Example METALS Project: Palo Alto Research Center (PARC) – "*Electrochemical Probe for Rapid Scrap Metal Sorting*" – Palo Alto, CA ($992,129).** PARC will develop a new electrochemical diagnostic probe that identifies the composition of light metal scrap for efficient sorting. Current sorting technologies for light metals are costly and inefficient because they cannot distinguish between different metals. If successful, PARC's electro-chemical diagnostic probe will enable the recycling of typically discarded light metal scrap.

- **REMOTE:** ***Reducing Emissions using Methanotrophic Organisms for Transportation Energy*** **($34,000,000)**
    - REMOTE will develop transformational biological technologies to convert gas to liquids (GTL) for transportation fuels. Current synthetic gas-to-liquids conversion approaches are technologically complex and require large, capital-intensive facilities, which limit widespread adoption. This program aims to lower the cost of GTL conversion while enabling the use of low-cost, low-carbon, domestically sourced natural gas.
    - **Example REMOTE Project: GreenLight Biosciences – "*Cell-Free Bioconversion for Access to Remote Natural Gas Sources*" – Medford, MA ($4,500,000).** GreenLight Biosciences will develop a cell-free bioreactor that can convert large quantities of methane to fuel in one step. This technology integrates the rapid conversion rate of chemical catalysis into a single-step bioconversion process that does not use traditional cells. If successful, it could enable mobile fermenters to access remote sources of natural gas for low-cost conversion of natural gas to liquid fuel.

- **SWITCHES:** ***Strategies for Wide Bandgap, Inexpensive Transistors for Controlling High Efficiency Systems*** **($27,000,000)**
    - The projects in SWITCHES are focused on developing next-generation power switching devices that could dramatically improve energy efficiency in a wide range of applications, including new lighting technologies, computer power supplies, industrial motor drives, and automobiles. Most of today's

high-voltage power electronics systems are based on silicon (Si) semiconductor devices, which have notable performance limitations. In contrast, SWITCHES projects are advancing bulk gallium nitride (GaN) power semiconductor devices, the manufacture of silicon carbide (SiC) devices using a foundry model, and the design of synthetic diamond-based transistors. These advances will enable increased switching frequency, enhanced temperature control, and reduced power losses, at substantially lower cost relative to today's solutions.

- Eight of the 14 SWITCHES projects are small businesses being funded through ARPA-E's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program.
- **Example SWITCHES Project: University of California at Santa Barbara (UCSB) – "*Current Aperture Vertical Electron Transistor Device Architectures for Efficient Power Switching*" – Santa Barbara, CA ($3,172,205).** The University of California, Santa Barbara (UCSB) will develop several new vertical gallium nitride (GaN) semiconductor technologies that will enhance the performance and reduce the cost of high-power electronics. The team's current aperture vertical electron transistor devices could reduce power losses and reach beyond the performance of lateral GaN devices when switching and converting power. If successful, UCSB's devices will enable high-power conversion at low cost in motor drives, electric vehicles, and power grid applications.
- **Example SWITCHES Project (SBIR/STTR): MicroLink Devices – "*Vertical-Junction Field-Effect Transistors Fabricated on Low-Dislocation-Density GaN by Epitaxial Lift-Off*" – Niles, IL ($1,725,000).** MicroLink Devices will engineer affordable, high-performance transistors needed for power conversion. Currently, high- performance power transistors are prohibitively expensive because they are grown on expensive gallium nitride (GaN) semiconductor wafers. In conventional manufacturing processes, this expensive wafer is permanently attached to the transistor, so the wafer can only be used once. MicroLink Devices will develop an innovative method to remove the transistor structure from the wafer without damaging any components, enabling wafer reuse that significantly reduce costs.

- **FOCUS: *Full-Spectrum Optimized Conversion and Utilization of Sunlight* ($30 Million)**
  - FOCUS seeks to develop new technologies that deliver cost-effective solar energy when the sun is not shining. The technologies developed will help advance solar energy beyond current photovoltaic (PV) and concentrated solar power (CSP) technologies to ensure solar power remains a consistent, cost-effective renewable energy option. The program is focused on two distinct technology options to deliver low-cost, high-efficiency solar energy on demand:

1. New hybrid solar energy converters that turn sunlight into electricity for immediate use, while also producing heat that can be stored at low cost for later use; these hybrid converters will use the entire solar spectrum more efficiently than PV or CSP technologies.
2. New hybrid energy storage systems that accept heat and electricity from variable solar sources to deliver electricity when needed.

- **Example FOCUS Project: Sharp Labs of America – "*High-Concentration Full-Spectrum Solar Energy System*" – Camas, WA ($4,182,929).** Sharp Labs of America will develop a hybrid solar converter that incorporates a partially transmitting mirror to reflect visible wavelengths of light to extremely high-efficiency solar cells while passing ultraviolet and most infrared light to heat a thermal fluid. The extremely high concentration of visible wavelengths of light would allow expensive solar cells to be used in an inexpensive converter. The converter could enable utilities to provide dispatchable, on-demand, solar electricity at low cost.

The table on the following page summarizes ARPA-E's programs to date. Please find a full list of the projects announced under ARPA-E's FY2013 FOAs in Appendix I. Additional information related to these projects can be found on ARPA-E's website: http://arpa-e.energy.gov.

ARPA-E Programs to Date			
	PROGRAM NAME	**NUMBER OF PROJECTS**	**FUNDING AMOUNT (Million $)**
EXISTING PROGRAMS	OPEN 2009	41	172.8
	Batteries for Electrical Energy Storage in Transportation (BEEST)	10	35.5
	Innovative Materials and Processes for Advanced Carbon Capture Technologies (IMPACCT)	14	41.0
	Electrofuels	13	48.7
	Agile Delivery of Electrical Power Technology (ADEPT)	14	37.7
	Building Energy Efficiency Through Innovative Thermodevices (BEET-IT)	17	35.6
	Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS)	12	34.0
	Plants Engineered to Replace Oil (PETRO)	10	55.0
	High Energy Advanced Thermal Storage (HEATS)	15	37.8
	Rare Earth Alternatives in Critical Technologies (REACT)	14	37.5
	Green Electricity Network Integration (GENI)	15	40.0
	Solar Agile Delivery of Electrical Power Technology (Solar ADEPT)	7	13.5
	Methane Opportunities for Vehicular Energy (MOVE)	13	37.6
	Advanced Management and Protection of Energy Storage Devices (AMPED)	14	30.2
	Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR)	6	12.8
	OPEN 2012	66	135.0
NEW IN FY2013	Robust Affordable Next Generation Energy Storage Systems (RANGE)*	22	36.0
	Reducing Emissions using Methanotrophic Organisms for Transportation Energy (REMOTE)*	15	34.0
	Modern Electro/Thermochemical Advancements for Light-metal Systems (METALS)*	18	32.0
	Full-Spectrum Optimized Conversion and Utilization of Sunlight (FOCUS)*	12	30.0
	Strategies for Wide Bandgap, Inexpensive Transistors for Controlling High Efficiency Systems (SWITCHES) & SBIR/STTR*	14	27.0

*RANGE, REMOTE, METALS, FOCUS, and SWITCHES project counts and funding amounts reflect information at the time of announcement. Final number of projects and funding amounts are subject to change based on contract negotiations.

IV. ARPA-E Energy Innovation Summit

The fourth annual ARPA-E Energy Innovation Summit was held from February 25-27, 2013. It brought together thought leaders from across the energy ecosystem – researchers, entrepreneurs, investors, corporate executives, and government officials – to discuss the foremost energy issues, cultivate relationships, and exchange ideas to advance cutting-edge technologies to market. The Summit's unique combination of leaders makes it the perfect forum for developing energy solutions that will enable the United States to maintain a global technological lead in advanced energy technology.

Throughout the three-day event, attendees also have the opportunity to explore the Technology Showcase which features ARPA-E awardees and a highly selective group of other companies, stakeholders, and research organizations. Many of these breakthrough technologies were demonstrated for the first time publicly during the Summit.

Program Highlights

- Over 2,200 attendees from 49 states, Puerto Rico, and over 20 countries
- Technology Showcase displaying more than 280 breakthrough energy technologies from ARPA-E awardees and other innovative companies
- Dynamic panel discussions and networking sessions that enabled participants to meet with ARPA-E Program Directors, global industry leaders and energy technologists
- 150+ expert speakers and keynote addresses, including leaders from Government, Business, and Academia
- Attendance and comments by a bipartisan group of United States Senators and Representatives
- Announcement that as of early 2013, ARPA-E had recognized several notable preliminary indicators of success, including:
    - 17 projects had attracted over $450 million in private sector follow-on funding after ARPA-E's initial investment of approximately $70 million
    - 12 projects had leveraged their technologies to form new companies
    - 10+ had partnered with other government agencies for later stage investment

V. Conclusion

In FY2013, ARPA-E announced five solicitations for focused programs for high-potential, transformational energy technologies. The programs created through these solicitations cover a wide range of technical areas, including electric vehicle energy storage systems, light-metal processing and recycling, biological gas-to-liquids conversion, high-efficiency transistors, and hybrid designs for solar power generation. Innovative projects in these five areas have the potential to transform the way we generate, store, and use energy in the United States.

At the 2013 Energy Innovation Summit, ARPA-E convened a diverse and influential group of energy experts and industry leaders focused on advancing the next generation of breakthrough energy technologies. The Summit brought together leaders with unique perspectives, experiences, and ideas with the shared goal of revolutionizing the American approach to energy innovation.

ARPA-E's mission is to quickly and efficiently catalyze energy breakthroughs that will enhance the economic and energy security of the United States through the development of transformational technologies that reduce America's dependence on energy imports; reduce U.S. energy related emissions; improve energy efficiency across all sectors of the U.S. economy; and ensure the U.S. maintains a technological lead in the development and deployment of advanced energy technologies. By attracting some of the best and brightest minds from emerging energy technology industries and focusing on overcoming major technical challenges, ARPA-E's work is catalyzing innovation and growth. Further, the Agency's Technology-to-Market program looks to provide awardees with the necessary tools and information to transition their technologies to the market. Technology-to-Market advisors work closely with project teams to help them build relationships and form partnerships that are necessary to move technologies to the next stage of project development.

Throughout FY 2013, ARPA-E has continued to demonstrate its dedication to supporting transformational projects. These breakthrough energy technologies present opportunities to revolutionize the ways we generate, store, distribute, and utilize energy in the United States.

VI. Appendix I: Fiscal Year 2013 Project Selectees

Figures listed below are as of the dates on which these project selections were publicly announced: August 21, 2013 (RANGE); September 19, 2013 (METALS and REMOTE); October 21, 2013 (SWITCHES); and February 6, 2014 (FOCUS).

Additional information on these projects is available on the ARPA-E website: http://arpa-e.energy.gov.

PROGRAM	LEAD ORGANIZATION	PROJECT TITLE	LOCATION	ARPA-E FUNDING[1] (Million $)
RANGE	University of Houston	**Advanced Aqueous Lithium-Ion Batteries**	Houston, TX	0.76
RANGE	EnZinc, Inc.	**Dendrite Free Zinc–Air Battery**	Emeryville, CA	0.45
RANGE	Princeton University	**Long-Life Rechargeable Alkaline Battery for EVs**	Princeton, NJ	0.96
RANGE	University of California, Los Angeles	**Long-Life, Acid-Based Battery**	Los Angeles, CA	0.50
RANGE	Jet Propulsion Laboratory	**Metal Hydride-Air Battery**	Pasadena, CA	2.83
RANGE	University of Maryland	**Multiple-Electron Aqueous Battery**	College Park, MD	0.41
RANGE	BASF	**Rare-Earth Free NiMH Alloy for EV Batteries**	Rochester Hills, MI	4.00
RANGE	General Electric	**Water-Based Flow Battery for EVs**	Niskayuna, NY	0.90
RANGE	Cloteam, LLC	**Low-Cost Electric Vehicle Battery Architecture**	Framingham, MA	3.50
RANGE	Stanford University	**Multifunctional Battery Chassis Systems**	Stanford, CA	2.71
RANGE	University of California, San Diego	**Multifunctional Battery Systems for Electric Vehicles**	San Diego, CA	3.50

[1] Figures represent funding amounts at the time of project announcements. Final amounts are subject to change based on contract negotiations.

RANGE	Arizona State University	**Multifunctional Cells for EVs**	Tempe, AZ	2.00
RANGE	Penn State University	**Structural Battery Power Panels**	University Park, PA	0.54
RANGE	Purdue University	**Impact-Tolerant EV Batteries**	West Lafayette, IN	0.50
RANGE	Quallion	**Lightweight Battery with Built-In Safety Features**	Sylmar, CA	0.51
RANGE	Illinois Institute of Technology	**Nanoelectrofuel Flow Battery for EVs**	Chicago, IL	3.41
RANGE	National Renewable Energy Laboratory	**Renewable Organics for Flow Battery**	Golden, CO	1.00
RANGE	Oak Ridge National Laboratory	**Impact-Resistant Electrolyte**	Oak Ridge, TN	0.45
RANGE	Ceramatec	**Advanced, Planar Lithium/Sulfur Batteries**	Salt Lake City, UT	2.97
RANGE	Solid Power, LLC	**All Solid-State Lithium-Ion Battery**	Louisville, CO	3.46
RANGE	Bettergy	**Beyond Lithium-Ion Solid-State Battery**	Peekskill, NY	0.39
RANGE	University of Maryland	**Solid-State Lithium-Ion Battery with Ceramic Electrolyte**	College Park, MD	0.57
REMOTE	Arzeda Corp.	**New Metalloenzymes for Methane Activation**	Seattle, WA	1.00
REMOTE	Lawrence Berkeley National Laboratory	**Enzyme Engineering for Direct Methane Conversion**	Berkeley, CA	3.50
REMOTE	MOgene Green Chemicals LLC	**Sunlight-Assisted Conversion of Methane to Butanol**	St. Louis, MO	1.45
REMOTE	Northwestern University	**Multicopper Oxidases for Methane Activation**	Evanston, IL	0.82
REMOTE	Pennsylvania State University	**Methane-to-Acetate Pathway for Liquid Fuel**	University Park, PA	3.00
REMOTE	University of Michigan	**Anaerobic Bioconversion of Methane to Methanol**	Ann Arbor, MI	3.00
REMOTE	Coskata, Inc.	**Activated Methane to Butanol**	Warrenville, IL	0.94

REMOTE	Massachusetts Institute of Technology	**Single-Step Methane Activation and Conversion to Liquid Fuels**	Cambridge, MA	3.00
REMOTE	University of California, Davis	**Biosynthetic Conversion of Ethylene to Butanol**	Davis, CA	1.50
REMOTE	University of California, Los Angeles	**Efficient Condensation Cycle for Methanol to Liquid Fuel**	Los Angeles, CA	3.00
REMOTE	University of Delaware	**Engineered Bioconversion of Methanol to Liquid Fuel**	Newark, DE	3.00
REMOTE	Calysta Energy	**New Bioreactor Designs for Rapid Methane Fermentation**	Menlo Park, CA	0.80
REMOTE	GreenLight Biosciences	**Cell-Free Bioconversion for Access to Remote Natural Gas Sources**	Medford, MA	4.50
REMOTE	LanzaTech, Inc.	**Bioreactor Design to Improve the Transfer of Methane to Microorganisms**	Roselle, IL	4.00
REMOTE	Oregon State University	**Bio-Lamina-Plates Bioreactor for Enhanced Mass and Heat Transfer**	Corvalis, OR	0.63
METALS	Alcoa, Inc.	**Advanced Aluminum Electrolytic Cell with Power Modulation and Heat Recovery**	Alcoa Center, PA	3.17
METALS	Gas Technology Institute (GTI)	**Dual Electrolyte and Electrolytic Membrane Extraction for Aluminum Production**	Des Plaines, IL	0.81
METALS	Infinium, Inc.	**Efficient Aluminum Production using Pure Oxygen Anodes**	Natick, MA	1.00
METALS	Pacific Northwest National Laboratory	**Catalyzed Organo-Metathetical Process for Magnesium Production from Seawater**	Richland, WA	2.43
METALS	University of Colorado	**Hybrid Solar/Electric Carbothermal Reactor for Magnesium Production**	Boulder, CO	3.60
METALS	Valparaiso University	**Solar-Thermal Electrolytic Production of Magnesium from Ore**	Valparaiso, IN	2.30
METALS	Case Western Reserve University	**Electrowinning Titanium Using Segmented Diaphragms**	Cleveland, OH	0.68
METALS	Titanium Metals Corporation (TIMET)	**Electrochemical Cell for Advanced Titanium Production**	Henderson, NV	1.66

METALS	iMetalx Group, LLC	**Electrowinning Titanium Using the Chinuka Process**	Pittsburgh, PA	2.68
METALS	SRI International (SRI)	**Direct Low-Cost Production of Titanium Alloys**	Menlo Park, CA	0.91
METALS	University of Utah	**Novel Chemical Pathway for Titanium Production**	Salt Lake City, UT	3.00
METALS	Research Triangle Institute	**High-Temperature Transfer and Storage System for Light Metal Production**	Research Triangle Park, NC	3.12
METALS	BlazeTech, Corp.	**Hyperspectral Imaging for Identification of Light Metal Alloys**	Woburn, MA	0.27
METALS	PARC	**Electrochemical Probe for Rapid Scrap Metal Sorting**	Palo Alto, CA	0.99
METALS	UHV Technologies, Inc.	**Low-Cost In-Line X-Ray Fluorescence Scrap Metal Sorter**	Fort Worth, TX	0.42
METALS	University of Utah	**Electromagnetic Sorting of Light Metals and Alloys**	Salt Lake City, UT	1.00
METALS	Energy Research Company	**Integrated Minimill to Produce Aluminum from Scrap**	Plainfield, NJ	3.00
METALS	Phinix, LLC	**Electrochemical Extraction of High Quality Magnesium from Scrap**	Lexington, KY	0.61
SWITCHES (SBIR/STTR)	Avogy, Inc.	**Vertical GaN Transistors on Bulk GaN Substrates**	San Jose, CA	1.73
SWITCHES (SBIR/STTR)	Fairfield Crystal Technology	**High Quality, Low-Cost GaN Single Crystal Substrates for High Power Devices**	New Milford, CT	1.43
SWITCHES (SBIR/STTR)	iBeam Materials, Inc.	**Epitaxial GaN on Flexible Metal Tapes for Low-Cost Transistor Devices**	Santa Fe, NM	0.79
SWITCHES (SBIR/STTR)	Kyma Technologies, Inc.	**High Quality, Low Cost GaN Substrate Technology**	Raleigh, NC	3.22
SWITCHES (SBIR/STTR)	MicroLink Devices	**Vertical-Junction Field-Effect Transistors Fabricated on Low-Dislocation-Density GaN by Epitaxial Lift-Off**	Niles, IL	1.73
SWITCHES (SBIR/STTR)	Monolith Semiconductor, Inc.	**Advanced Manufacturing and Performance Enhancements for Reduced Cost Silicon Carbide MOSFETs**	Ithaca, NY	3.22

SWITCHES (SBIR/STTR)	SixPoint Materials, Inc.	**GaN Homoepitaxial Wafers by Vapor Phase Epitaxy on Low-Cost, High-Quality Ammonothermal GaN Substrates**	Buellton, CA	$1.73
SWITCHES (SBIR/STTR)	Soraa, Inc.	**Large Area, Low-Cost Bulk GaN Substrates for Power Electronics**	Fremont, CA	0.23
SWITCHES	Arizona State University	**Diamond Power Transistors Enabled by Phosphorus Doped Diamond**	Tempe, AZ	0.42
SWITCHES	Columbia University	**Vertical GaN Power Transistors Using Controlled Spalling for Substrate Heterogeneity**	New York, NY	3.00
SWITCHES	HRL Laboratories, LLC	**Low-Cost Gallium Nitride Vertical Transistor**	Malibu, CA	2.90
SWITCHES	Michigan State University	**Diamond Diode and Transistor Devices**	East Lansing, MI	0.56
SWITCHES	University of California, Santa Barbara	**Current Aperture Vertical Electron Transistor Device Architectures for Efficient Power Switching**	Santa Barbara, CA	3.17
SWITCHES	University of Notre Dame	**PolarJFET Novel Vertical GaN Power Transistor**	St. Joseph, IN	2.50
FOCUS	Arizona State University	**High-Temperature Topping Cells from LED Materials**	Tempe, AZ	3.90
FOCUS	Arizona State University	**Solar-Concentrating Photovoltaic Mirrors**	Tempe, AZ	2.64
FOCUS	Cogenra Solar, Inc.	**Double-Focus Hybrid Solar Energy System with Full Spectrum Utilization.**	Mountain View, CA	2.00
FOCUS	Gas Technology Institute	**Double-Reflector Hybrid Solar Energy System**	Des Plaines, IL	0.99
FOCUS	General Electric Global Research	**Electrothermal Energy Storage with a Supercritical CO2 Cycle**	Niskayuna, NY	2.28
FOCUS	Massachusetts Institute of Technology	**Full-Spectrum Stacked Solar-Thermal and PV Receiver**	Cambridge, MA	3.42
FOCUS	Massachusetts Institute of Technology	**Low-Cost Hetero-Epitaxial Solar Cell for Hybrid Converter**	Cambridge, MA	0.59
FOCUS	MicroLink Devices	**Epitaxial Lift-Off III-V Solar Cell for High Temperature Operation**	Niles, IL	3.60
FOCUS	Northrop Grumman Aerospace Systems	**Thermo-Acoustic PV Hybrid Solar Energy System**	Redondo Beach, CA	2.36

FOCUS	Otherlab	**Hybrid Solar Converter with Solar Pond Receiver**	San Francisco, CA	3.00
FOCUS	Sharp Labs of America	**High-Concentration Full-Spectrum Solar Energy System**	Camas, WA	4.18
FOCUS	The University of Tulsa	**Liquid Filter with Plasmonic Nanoparticles**	Tulsa, OK	1.76