OPEN 2012 Program Overview

C. PROGRAM OVERVIEW

Over a remarkably short period of time – from the early 19th Century forward – the production, distribution and use of energy completely reshaped the United States, including tremendous changes to how Americans live, travel and work. The production of massive quantities of fungible energy – as electricity, liquid fuels and natural gas – entirely transformed the American economy, enabling manufacturing at massive levels, and providing a suite of goods and services entirely unimaginable even a few decades ago.

Today, the United States ranks second in the world in overall energy use, and seventh in per capita energy consumption. The United States comprises some 5% of the world's population but consumes more than a quarter of the total energy produced worldwide. Although per capita energy demand has remained relatively constant in the United States over the last several decades (due in part to increased energy efficiency and the movement of manufacturing overseas), the energy demands of emerging economies is growing rapidly and will continue to grow over the coming decades, in lockstep with rising standards of living. This growth will inevitably strain the finite resources of the planet.

Despite the rapid development and deployment of renewable resources, the energy economy of the United States remains largely based on hydrocarbon resources, including oil, coal, and natural gas. Although the United States possesses significant quantities of some hydrocarbon resources, others are already insufficient to meet domestic demand, and even those resources that are plentiful are finite and will eventually be depleted. Today the United States imports some 9 million barrels of oil per day, roughly half the country's total need, at a cost of nearly $1 billion per day and accounting for over a third of the U.S. trade deficit. Both coal and natural gas exports from the United States to developing economies will increase price pressures on these vital resources.

Given the inexorable increase in demand for energy services, both in the United States and world-wide, there is a tremendous need for revolutionary approaches to the generation, transmission and use of energy and energy services. This FOA intends to address those needs, by supporting revolutionary technological advances across the entire energy space.

D. PROGRAM OBJECTIVES

To address the challenges imposed by the rapidly evolving global energy market, ARPA-E seeks to support transformational research in all areas of energy R&D, including resource identification, extraction, transportation and use, and energy generation, storage, transmission and use in both the transportation and stationary power sectors. Areas of research responsive to this FOA include (but are not limited to) electricity generation by both renewable and non-renewable means, electricity transmission, storage, and distribution; energy efficiency for buildings, manufacturing and commerce, and personal use; and all aspects of transportation, including the production and distribution of both renewable and non-renewable fuels, electrification, and energy efficiency in transportation.

The result of a successful ARPA-E project will be such that at the end of the project the transformational technology will be sufficiently advanced and well defined in terms of performance and risk to promote next-stage development or transfer of the project to next-stage developers. Projects under this FOA must be aimed at *more than progress toward* identified project goals; the project must be aimed at *actual delivery* of these project goals. The R&D effort on later-stage technology development projects must carry the risk reduction process for the technology to the point at which entrepreneurial decisions can be made with confidence.

E. TECHNICAL CATEGORIES AND SUBCATEGORIES OF INTEREST

Applicants may propose any idea that addresses ARPA-E's Mission Areas and the types of projects that ARPA-E funds, as described in Section I.A of the FOA. These ideas may span multiple disciplinary boundaries. Each Notice of Intent,

Concept Paper, and Full Application must identify the Technical Subcategory or Subcategories for the proposed technology. Applicants may select a single Technical Subcategory or multiple Technical Subcategories for their proposed technology, as appropriate. The Applicant may select multiple Technical Subcategories from the same Technical Category or different Technical Categories. See the chart below for the list of Technical Categories and Subcategories.

The list of Technical Subcategories is intended to encompass the full range of energy-related technologies. If the proposed technology does not fall within one or more of the Technical Subcategories below, the Applicant should select Subcategory A ("Technologies Which Do Not Fit In Any Of The Above Categories") within Category 8, "None of the Above."

CATEGORY	SUBCATEGORY	DESCRIPTION
CATEGORY 1: RENEWABLE POWER (NON-BIO)	**Subcategory A: Wind - Energy Capture**	Technologies that lead to better capture of wind resources. This could include different configurations, blade designs and materials. Also in this category could be tools for wind resource identification, classification, and modeling.
	Subcategory B: Wind - Energy Conversion	Technologies that lead to better conversion of wind power into useable energy, such as motors and magnetic materials, electronics, etc. specifically designed for wind energy.
	Subcategory C: Geothermal Energy	Geothermal heat technologies including pumps, proppants, induced seismicity, enhanced geothermal systems (EGS), drilling, resource identification (sensors, models, tracers), zonal isolation techniques, robust equipment, low temperature generation, etc.
	Subcategory D: Hydro Energy	Technologies for capturing and/or converting hydrokinectic energy such as ocean, osmotic, tidal, etc.
	Subcategory E: Solar - PV/CPV	Technologies for solar PV/CPV systems including materials, cell configurations, BOS and other technologies for solar cells that convert light into electricity or fuel.
	Subcategory F: Solar – Non-PV	Technologies for non-PV solar systems and sub-systems including solar thermal, materials, configurations, BOS and other technologies that use or convert energy without direct photovoltaic conversion.
	Subcategory G: Power Electronics - Renewable Generation	Technologies which include semiconductor designs and materials, circuit designs, magnetic materials, capacitors, switches, etc. applied to renewable power generation.
	Subcategory H: Renewable Power - Other	Renewable energy technologies that do not fit one of the above categories. Including, but not limited to, solar concentrators, methods for cheaper installation, resource identification and modeling, sensors, combined processes, catalysts for water oxidation, etc.

CATEGORY 2: BIOENERGY	**Subcategory A: Biomass Production**	Technologies which improve biomass characteristics, such as yield and sustainability, and decrease cost of production and/or water use.
	Subcategory B: Biofuel Production - Biological Methods	Technologies which utilize a biological agent in one or more principle step(s) of feedstock conversion to fuels.
	Subcategory C: Biofuel Production - Nonbiological Methods	Technologies which do not utilize any biological agent in the conversion of organic feedstock to fuels, such as thermochemical and hybrid approaches or biomimetics.
	Subcategory D: Bioenergy Supply Chain	Technologies critical to supply chain development, such as feedstock collection and handling.
	Subcategory E: Bioenergy - Other	Transformational technologies for bioenergy which do not fit in one of the above bins. Including but not limited to bioreactors, balance of plant, bioproducts, microbial fuel cells, sensors.
CATEGORY 3: TRANSPORTATION	**Subcategory A: Alternative Fuels (Non-Bio)**	Technologies which create fuels that are substitutes for gasoline/diesel, but are not bio based.
	Subcategory B: Engines - Transportation	Technologies for improved internal combustion engines and other engine types (i.e., turbines) specifically for transportation applications.
	Subcategory C: Electric Motors – Transportation	Technologies for improved electric motors specifically for transportation application.
	Subcategory D: Fuel Cells - Transportation	Technologies for improved fuel cells specifically for transportation application.
	Subcategory E: Advanced Vehicle Designs And Materials	Advanced or alternative vehicle designs and/or key enabling technologies. Examples could include ultralightweight vehicles, advanced components, new vehicle designs and architectures, etc.

	Subcategory F: Transportation Management	Technologies for traffic management, transportation behavior, self-driving cars and other advanced transportation management scenarios.
	Subcategory G: Power Electronics - Transportation	New semiconductor designs and materials, circuit designs, magnetic materials, capacitors, switches, packaging, thermal management systems, etc. or optimizations of electronic systems applied to specifically to transportation applications.
	Subcategory H: Non-Vehicular Transportation	Technologies for advanced airplanes, human powered vehicles, marine, trains, etc.
	Subcategory I: Batteries - Transportation	Technologies for improved batteries for a wide range of vehicle applications, including hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (EVs).
	Subcategory J: Non-Battery Storage For Transportation	Technologies which apply thermal storage, and non-battery electric storage, such as supercapacitors and others specifically for transportation application.
	Subcategory K: Transportation - Other	Transformational transportation energy technologies that do not fit one of the above categories, including but not limited to wireless charging technologies, advanced transportation infrastructure, etc.
CATEGORY 4: CONVENTIONAL GENERATION (NON-RENEWABLE)	**Subcategory A: Combined Processes - Conventional Generation**	Improved conventional generation designs which use a combination of technologies (for example- fuel cells and turbines).
	Subcategory B: Stationary Engines/Turbines For Conventional Generation	Improved engines/turbines for conventional generation applications.
	Subcategory C: Stationary Fuel Cells For Conventional Generation	Improved fuel cells intended to be coupled with conventional generation sources.
	Subcategory D: Nuclear Power Generation	Technologies which enhance fission, fusion, or materials specifically for safe nuclear power generation.

	And Materials	
	Subcategory E: Carbon Capture, Use, And Storage	Technologies for carbon capture, use, and storage.
	Subcategory F: Exploration And Extraction (Non-Geothermal) Of Conventional Resources	Technologies/tools for resource identification, classification, and modeling, as well as technologies to extract conventional resources. This bin can include sensors and imaging technologies, predictive models and algorithms, drills, pumps, methodologies for water treatment and reuse, etc.
	Subcategory G: Planning And Operations For Conventional Generation	Technologies which improve the planning and operation of conventional power generation.
	Subcategory H: Combustible Gas Infrastructure	Technologies for storage, transportation and/or handling of combustible gases. This could include tanks, pipelines, pumps, etc.
	Subcategory I: Chemical and Biological Conversions From Fossil	Technologies which improve chemical or biological conversions of fossil resources such as gas to liquids (GTL), coal to liquids (CTL), and other forms of energy transduction.
	Subcategory J: Water Conservation In Conventional Generation	Technologies which will enable significant water savings in the generation of power, such as water recovery/recirculation systems or dry cooling of power plants.
	Subcategory K: Conventional Generation – Other	Transformational conventional generation technologies that do not fit into one of the categories above.
CATEGORY 5: GRID	**Subcategory A: Grid Transmission**	Technologies for transmission systems (>69 kV) and operations.
	Subcategory B: Grid Distribution	Technologies for medium voltage distribution systems (≤69 kV) and operation.

	Subcategory C: Modeling, Software, Algorithms, And Control For The Grid	Modeling or algorithms that describe grid operations, including market modeling.
	Subcategory D: Batteries - Grid Scale	Grid scale battery technologies.
	Subcategory E: Grid Scale (Non-Battery) Storage	Non-battery technologies for grid-scale storage such as: pumped-hydro, compressed air, high angular velocity flywheels, thermal storage, etc.
	Subcategory F: Grid Security Reliability, and Resilience	Advanced concepts in cybersecurity, as well as fault protection (transmission or distribution) technologies, and technologies to autonomously maintain function and security of the grid.
	Subcategory G: Grid – Other	Grid technologies that do not fit into one of the above categories. Includes, but not limited to: balance of plant, power plant interface to transmission, sensors, etc.
CATEGORY 6: BUILDING EFFICIENCY	**Subcategory A: CHP**	Technologies which improve current Combined Heat and Power (CHP) designs/scenarios.
	Subcategory B: Building Heating and Cooling	Technologies which significantly improve the efficiency of building heating and cooling systems.
	Subcategory C: Building Energy Demand Management	Demand response technologies such as smart meters, other building energy conservation technologies such as automatic control systems.
	Subcategory D: Lighting	Energy efficient and environmentally-friendly advanced lighting technologies.
	Subcategory E: Building Envelope	Building designs leading to better energy efficiency, technologies could be applied to windows, insulation, roofing, etc.
	Subcategory F: Building Efficiency - Other	Building energy efficiency technologies that do not fit into one of the categories above.

CATEGORY 7: OTHER	**Subcategory A: Water Production/Reuse**	Technologies which could enable cost-effective ways of providing fresh water.
	Subcategory B: Thermal Energy Storage	Thermal energy storage technologies that can apply to multiple applications.
	Subcategory C: Advanced Manufacturing	Innovative technologies for advanced manufacturing.
	Subcategory D: Behavior/Education	Socio-economic energy technologies, research and/or education to use energy in efficient ways, or behave in such a way that leads to more optimal use of energy.
	Subcategory E: Appliance And Consumer Electronics Efficiency (End Use)	Technologies which significantly improve the efficiency of appliances and consumer electronics, including but not limited to: refrigerators, washers, dryers, televisions, stoves, laptops, phones, etc.
	Subcategory F: Data Centers And Computation	Technologies to improve the energy efficiency of computing devices and computational infrastructure.
	Subcategory G: Industrial Efficiency – Materials	Technologies which improve the efficiency of industrial materials. Including but not limited to glass, paper, iron, steel, plastics, aluminum, etc.
	Subcategory H: Industrial Efficiency – Other	Technologies which improve the efficiency of industrial processes which are not covered by other bins.
	Subcategory I: Heat Recovery	Technologies for heat recovery including but not limited to thermoelectrics, Sterling engines, heat exchangers, conversion of waste heat, bottoming cycles, heat capture methods, materials, devices, etc.
	Subcategory J: High Temperature Materials	Materials designed specifically to withstand extremely high temperatures in order to enable new energy generation technologies.
	Subcategory K: Semiconductors	Technologies which enable the development of new semiconductor materials or the use of semiconductor materials in innovative applications.

	<u>Subcategory L</u>: Portable Power	Technologies for portable power applications such as piezoelectrics, portable fuel cells, batteries, etc.
	<u>Subcategory M</u>: Critical Materials	Technologies which reduce or replace energy critical materials including but not limited to alternatives for magnetics, phosphors, catalysts. This could also include advanced technologies for extracting, processing, and/or recycling of critical materials.
<u>CATEGORY 8</u>: NONE OF THE ABOVE	**<u>Subcategory A</u>: Technologies That Do Not Fit In Any Of The Above Categories and Subcategories**	

F. APPLICATIONS SPECIFICALLY NOT OF INTEREST

The following types of applications will be deemed nonresponsive and will not be reviewed or considered (see Section III.C.2 of the FOA):

- Applications that fall outside the "Technical Categories and Subcategories of Interest" specified in Section I.E of the FOA.
- Applications that were already submitted to pending ARPA-E FOAs.
- Applications that are not scientifically distinct from applications submitted to pending ARPA-E FOAs.
- Applications for basic research aimed at discovery and fundamental knowledge generation.
- Applications for large-scale demonstration projects of existing technologies.
- Applications for proposed technologies that represent incremental improvements to existing technologies.
- Applications for proposed technologies that are not based on sound scientific principles (e.g., violates a law of thermodynamics).
- Applications that do not address at least one of ARPA-E's Mission Areas (see Section I.A of the FOA).
- Applications for proposed technologies that are not transformational, as described in Section I.A of the FOA. Transformational, as illustrated in Figure 1 in Section I.A of the FOA, is the promise of high payoff in some sector of the energy economy.
- Applications for proposed technologies that do not have the potential to become disruptive in nature, as described in Section I.A of the FOA. Technologies must be scalable such that they could be disruptive with sufficient technical progress (see Figure 1 in Section I.A of the FOA).