FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

ADVANCED RESEARCH PROJECTS AGENCY – ENERGY (ARPA-E)
U.S. DEPARTMENT OF ENERGY

MODERN ELECTRO/THERMOCHEMICAL ADVANCES IN LIGHT-METAL SYSTEMS (METALS)

Announcement Type: ~~Modification 001~~ Modification 002
Funding Opportunity No. DE-FOA-0000882
CFDA Number 81.135

FOA Issue Date:	March 20,2013
First Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, April 15, 2013
Submission Deadline for Concept Papers:	5 PM ET, April 22, 2013
Second Deadline for Questions to ARPA-E-CO@hq.doe.gov:	~~TBD~~5 PM ET, July 1, 2013
Submission Deadline for Full Applications:	~~TBD~~5 PM ET, July 8, 2013
Submission Deadline for Replies to Reviewer Comments:	~~TBD~~5 PM ET, August 9, 2013
Expected Date for Selection Notifications:	~~TBD~~5 PM ET, August 2013
Total Amount to Be Awarded	Approximately ~~$20~~ $30 million, subject to the availability of appropriated funds.
Anticipated Awards	ARPA-E may issue one, multiple, or no awards under this FOA. Awards may vary between $250,000 and $10 million.

- For eligibility criteria, see Section III.A of the FOA.
- For cost share requirements under this FOA, see Section III.B of the FOA.
- To apply to this FOA, Applicants must register with and submit application materials through ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/Registration.aspx). For detailed guidance on using ARPA-E eXCHANGE, see Section IV.H.1 of the FOA.
- Applicants are responsible for meeting each submission deadline. Applicants are strongly encouraged to submit their applications at least 48 hours in advance of the submission deadline.
- ARPA-E will not review or consider noncompliant or nonresponsive applications. For detailed guidance on compliance and responsiveness criteria, see Sections III.C.1 and III.C.2 of the FOA.

Questions about this FOA? Email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A.
Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

MODIFICATIONS

All modifications to the Funding Opportunity Announcement (FOA) are highlighted in yellow in the body of the FOA.

Mod. No.	Date	Description of Modifications
01	03/26/13	• Included reference for definition of "Processing Energy" on page 6. • Added definition of "Processing Energy" in Section IX Glossary on page 54.
02	05/21/13	• Inserted certain deadlines, including the deadlines for the submission of Full Applications and Replies to Reviewer Comments. See Cover Page and Required Documents Checklist. • Updated total amount to be awarded to $30 million. See Cover Page and Section II.A. • Inserted anticipated dates for selection announcement and award of funding agreements. See Cover Page and Section V.C of the FOA. • Revised the following sections of the FOA to provide guidance on required application forms and the content and form of Full Applications and Replies to Reviewer Comments: Required Documents Checklist and Sections IV.D, IV.E, IV.G of the FOA. Applicants are required to use the following templates provided on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov) to complete certain parts of their Full Applications: Template Technical Volume of the Full Application, Technical Milestones and Deliverables- Instructions and Examples, , Template Summary Slide, Template Summary for Public Release, and Template Reply to Reviewer Comments. • Inserted criteria that ARPA-E will use to evaluate Full Applications. See Section V.A.2 of the FOA. • Inserted criteria that ARPA-E will use to evaluate Replies to Reviewer Comments in Section V.A.3 of the FOA. • Inserted program Policy Factors. See Section V.B.1 of the FOA. • Inserted Full Application Notification language. See Section VI.A.3 of the FOA. • Inserted Administrative and National Policy Requirements. See Section VI.B of the FOA. • Inserted Reporting requirements. See Section VI.C of the FOA. • Clarified that ARPA-E awards may not be transferred, assigned, or assumed without the prior written consent of a Contracting Officer. See Section VIII.B of the FOA. • Clarified that if entities elect to retain title to subject inventions, they must file a patent application in a timely fashion. See Section VIII.F of the FOA. • Clarified the conditions under which the U.S. Government may exercise its March-in Rights. See section VIII.G.2 of the FOA. • Inserted information concerning annual compliance audits for for-profit Entities. See Section VIII.J of the FOA.

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REQUIRED DOCUMENTS CHECKLIST

For an overview of the application process, see Section IV.A of the FOA.

For guidance regarding requisite application forms, see Section IV.B of the FOA.

For guidance regarding the content and form of Concept Papers, Full Applications, and Replies to Reviewer Comments, see Sections IV.C, IV.D, and IV.E of the FOA.

SUBMISSION	COMPONENTS	OPTIONAL/ MANDATORY	FOA SECTION	DEADLINE
Concept Paper	• Each Applicant must submit a Concept Paper in Adobe PDF format by the stated deadline. The Concept Paper must include the following: o Technology Description (2 pages max.) o Addendum (2 pages max.)	Mandatory	IV.C	5 PM ET, April 22, 2013
Full Application	~~[TO BE INSERTED BY FOA MODIFICATION IN [May 2013]~~ • Each Applicant must submit a Technical Volume in Adobe PDF format by the stated deadline. Applicants must use the Technical Volume template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). The Technical Volume must include the following: o Technical Approach (1 page max.) o R&D Tasks (1 page max.) o R&D Strategy (20 pages max.) o Technology-to-Market Strategy (2 pages max.) o Budget Summary (2 pages max.) o Qualifications, Experience, and Capabilities (3 pages max. for each Personal Qualifications Summary) o Participating Organizations (1 page max.) o Prior Collaboration (1 page max.) o Management Plan (1 page max.) o Multi-Investigator Projects (2 pages max.) o Intellectual Property Strategy (no page limit) • The Technical Volume must be accompanied by: o SF-424 (no page limit, Adobe PDF format); o Budget Justification Workbook/SF424A (no page limit, Microsoft Excel format) o Technical Milestones and Deliverables (10 pages max.) – Applicants must refer to the Technical Milestones and Deliverables - Instructions and Examples document available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov) o Summary for Public Release (1 page max., Adobe PDF format); o Summary Slide (1 page limit, Microsoft PowerPoint format) – Applicants must use the Summary Slide template available on ARPA-E eXCHANGE	Mandatory	IV.D	~~TBD~~5 PM ET, July 8, 2013

	(https://arpa-e-foa.energy.gov); o Completed and signed Business Assurances Form (no page limit, Adobe PDF format); and o Completed and signed Other Sources of Funding Disclosure form (no page limit, Adobe PDF format).			
Reply to Reviewer Comments	~~[TO BE INSERTED BY FOA MODIFICATION IN [May 2013]~~ • Each Applicant may submit a Reply to Reviewer Comments in Adobe PDF format. This submission is optional. Applicants must use the Reply to Reviewer Comments template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). The Reply may include: o Up to 2 pages of text; and o Up to 1 page of images.	Optional	IV.E	~~TBD~~5 PM ET, August 9, 2013

I. FUNDING OPPORTUNITY DESCRIPTION

A. AGENCY OVERVIEW

The Advanced Research Projects Agency – Energy (ARPA-E), an organization within the Department of Energy, is chartered by Congress in the America COMPETES Act of 2007 (P.L. 110-69), as amended by the America COMPETES Reauthorization Act of 2010 (P.L. 111-358), to support the creation of transformational energy technologies and systems through funding and managing Research and Development (R&D) efforts. Originally chartered in 2007, the Agency was first funded through the American Recovery and Reinvestment Act of 2009. Since that time, the Agency has funded about 285 projects totaling approximately $770 million across the entire technology landscape.[1]

The mission of ARPA-E is to identify and fund research to translate science into breakthrough energy technologies that are too risky for the private sector and that, if successfully developed, will create the foundation for entirely new industries. Successful projects will address at least one of ARPA-E's two Mission Areas:

1. Enhance the economic and energy security of the United States through the development of energy technologies that result in:
   a. reductions of imports of energy from foreign sources;
   b. reductions of energy-related emissions, including greenhouse gases; and
   c. improvement in the energy efficiency of all economic sectors; and
2. Ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies.

ARPA-E funds applied research and development. ARPA-E exists to fund applied research and development, defined by the Office of Management and Budget as a "study (designed) to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met" and as the "systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements." ARPA-E funds technology-focused applied research to create scalable solutions to important problems in energy creation, distribution and use and, as such, will not support basic research, defined as a "systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind." While it is anticipated that in some instances some minor aspects of fundamental science will be clarified or uncovered during the conduct of the supported applied research, the major portion of activities supported by ARPA-E are directed towards applied research and development of new technologies.

[1] Information on ARPA-E's projects is available at http://arpa-e.energy.gov/?q=projects.

While all technology-focused applied research will be considered, two instances are especially fruitful for the creation of transformational technologies:

- the first establishment of a technology upon recently elucidated scientific principles; and
- the synthesis of scientific principles drawn from disparate fields that do not typically intersect.

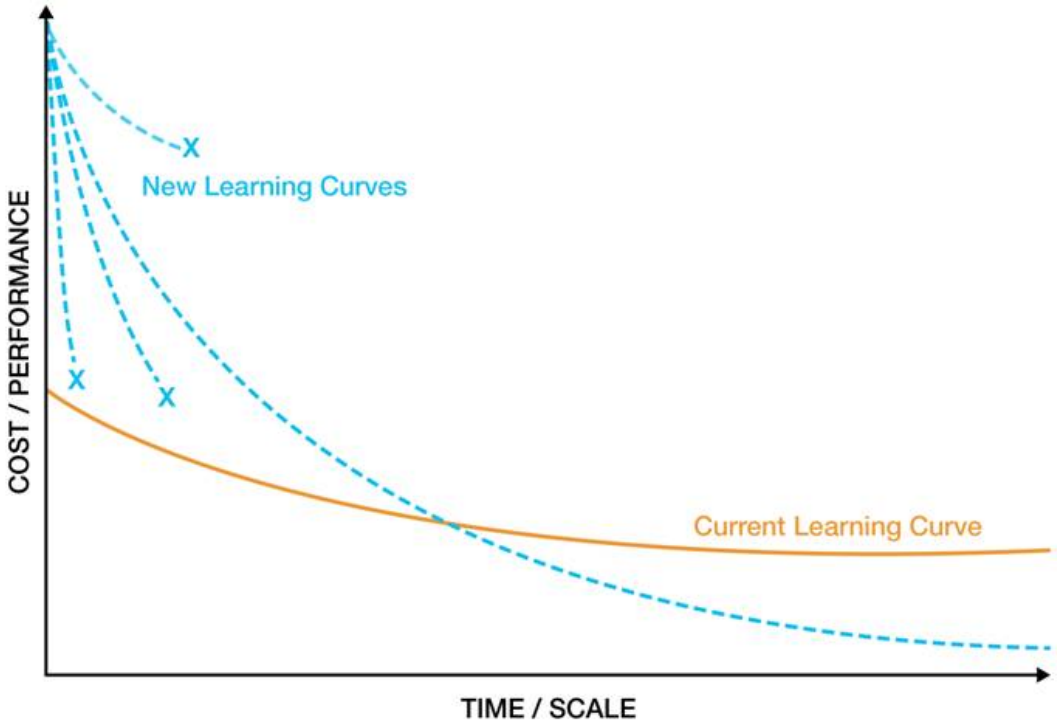

Figure 1: Description of transformational and disruptive technologies in terms of cost, performance, and scale. ARPA-E supports research that establishes new learning curves. A transformational technology becomes disruptive after passing the tipping point.

ARPA-E exists to support transformational, rather than incremental research. Technologies exist on learning curves (Figure 1). Following the creation of a technology, refinements to that technology and economies of scale that accrue as manufacturing and widespread distribution develop drive technology down that learning curve until an equilibrium price is found. While this incremental improvement of technology is important to the ultimate success of a technology in the marketplace, ARPA-E exists to fund transformational research – i.e., research that creates fundamentally new learning curves rather than moving existing technologies down their learning curves.

ARPA-E funded technology has the potential to be disruptive in the marketplace. The mere creation of a new learning curve does not ensure market penetration. Rather, the ultimate value of a technology is determined by the marketplace, and impactful technologies ultimately become disruptive – that is, they are widely adopted and displace existing technologies from the marketplace or create entirely new markets. Energy technologies typically become disruptive at maturity rather than close to inception and the maturation of nascent technologies often require significant incremental development to drive the technology down its natural learning curve to its ultimate equilibrium (see Figure 1 above). Such development might include modification of the technology itself, the means to produce and distribute that technology, or both. Thus, while early incarnations of the automobile were transformational in the sense that they created a fundamentally new learning curve for transportation, they were not disruptive, because of the unreliability and high cost of early automobiles. Continuous, incremental refinement of the technology ultimately led to the Ford Model T: as the first affordable, reliable, mass-produced vehicle, the Model T had a disruptive effect on the transportation market.

ARPA-E will not support technology development for extended periods of time; rather, ARPA-E supports the initial creation of technology. Following initial testing of the first prototype of a device, a system, or a process, other Federal agencies and the private sector will support the incremental development necessary to bring the technology to market.

While ARPA-E does not require technologies to be disruptive at the conclusion of ARPA-E funding, ARPA-E will not support technologies that cannot be disruptive even if successful. Examples of such technologies are approaches that require elements with insufficient abundances of materials to be deployed at scale, or technologies that could not scale to levels required to be impactful because of, for example, physical limits to productivity.

ARPA-E will not support basic research aimed at discovery and fundamental knowledge generation, nor will it undertake large-scale demonstration projects of existing technologies. ARPA-E is not a substitute for existing R&D organizations within the Department of Energy, but rather complements existing organizations by supporting R&D objectives that are transformational and translational. Applicants interested in receiving basic research financial assistance should work with the Department of Energy's Office of Science (http://science.energy.gov/). Similarly, projects focused on the improvement of existing technology platforms may be appropriate for support by the applied programs – for example, the Office of Energy Efficiency and Renewable Energy (http://www.eere.energy.gov/), the Office of Fossil Energy (http://fossil.energy.gov/), the Office of Nuclear Energy (http://nuclear.energy.gov/), and the Office of Electricity Delivery and Energy Reliability (http://energy.gov/oe/office-electricity-delivery-and-energy-reliability).

B. PROGRAM OVERVIEW

This program seeks to fund transformative new technologies for the primary processing of light metals (Al, Mg, and Ti) and for their cost effective, domestic recycling. These metals are widely viewed as essential to achieving substantial energy savings and reduced carbon emissions through lightweighting in both automotive and aircraft applications; however their widespread adoption will only be realized when they are produced with lower costs, less energy consumption, and reduced carbon emissions so that they are competitive with incumbent structural metals - steel and stainless steel. Of particular interest to primary light metal production are integrated system approaches that allow for one or more of the following operational characteristics: variable energy inputs (including renewable energy), high temperature heat recovery, high temperature thermal storage, and use of domestically abundant ores. Of particular interest to light metal recycling are transformative technologies and processes that enable rapid, high precision, and automated sorting of metals and alloys that are or can be integrated with high efficiency secondary light metal production. Innovative concepts focused on energy intensive and/or high cost stages of both the primary and secondary production processes will also be considered.

The impact of technologies successfully emerging from the program will be to provide substantial benefits germane to the ARPA-E mission, including reduced domestic energy consumption, reduced emissions, and a technological lead in advanced light metal production technologies. These technologies could have both a transformative and disruptive impact on the global structural metals market.

1. Background

The light metals Aluminum (Al), Magnesium (Mg), and Titanium (Ti) have the potential to play a significant enabling role in future energy savings across a wide range of applications, including but not limited to: transportation, power production, industrial processing, and structures [1-3]. The high strength-to-weight ratios of these metals means that their use in automotive manufacturing produces more fuel efficient vehicles with no reduction in performance or safety. Titanium has superb native corrosion resistance, while aluminum is typically alloyed with magnesium to give it more ductility, weldability, and corrosion resistance. As shown in Table 1, aluminum and magnesium have strength-to-weight ratios of 130 kNm/kg and 158 kNm/kg, whereas that of steel is 38 kNm/kg. Their respective costs of $2.00/kg and $3.31/kg, as compared to steel at $0.47/kg, indicate that cost is a barrier to adoption in many applications [2,4-7]. Similarly, as shown in Table 2, titanium has the potential to compete with 304 stainless steel in many applications, where the respective strength-to-weight ratios are 120 kNm/kg and 77 kNm/kg. However at comparative costs of $9.00/kg (Ti sponge powder) and $2.40/kg [8-11], cost is also a barrier. In order to achieve the large energy reductions that is possible with greater use of magnesium and aluminum, the primary processing of light metals must reach parity with steel on cost, energy consumption, and CO_2 emissions. Radical new approaches to the processing of light metals are needed to reach parity with steel (Mg and Al) and stainless steel (Ti).

Table 1: Strength, energy, emissions, cost, and density for aluminum, magnesium, and steel [4-7].

	Aluminum	Magnesium	Steel
Strength-to-Weight Ratio (kNm/kg)	130	158	38
Processing Energy* (kWh/kg)	*Hall-Heroult*: 56	*Western Electrolytic:* 43.6 *Pidgeon Process*: 102	6.4
Theoretical Minimum Energy (kWh/kg)	*7.5*	*5.8*	2.4
Emissions ($kgCO_2/kg$)	*Hall-Heroult:* 22	*Western Electrolytic:* 6.9 *Pidgeon Process:* 37	2.3
Domestic Production Cost ($/kg)	2.00	3.31	0.47
Density (kg/m^3)	2700	1800	7870

*Please see Section IX (Glossary) for definition of Processing Energy.

Table 2: Strength, energy, emissions, cost, and density for titanium and stainless steel [8-11].

	Titanium	Stainless Steel (Type 304)
Strength-to-Weight Ratio (kNm/kg)	120	77
Processing Energy (kWh/kg)	*Kroll Process:* 100	21
Theoretical Minimum Energy (kWh/kg)	*4.7*	**Not Available*
Emissions ($kgCO_2/kg$)	*Kroll Process:* 36	*6.8*
Domestic Production Cost ($/kg)	*Sponge:* 9.00	2.40
Density (kg/m^3)	4500	8030

As shown in Figure 2, the major components contributing to the cost of light metals are raw materials, labor, capital, and energy [7]. Processing of light metals has very poor energy efficiency, as revealed from comparing current processing energies to theoretical minimum processing energies in Tables 1 and 2 [12]. These poor energy efficiencies translate directly into large carbon emissions. A comparison of carbon emissions for producing aluminum and magnesium versus steel is also shown in Table 1, while that for titanium versus stainless steel is shown in Table 2; light metals are also systematically more energy and carbon intense to produce relative to the incumbent structural metals, steel and stainless steel. Thus it is a goal of this program to support the development of transformational new technologies that would enable light metals (aluminum, magnesium and titanium) to be cost competitive with the incumbent structural metals (steel and stainless steel), but also with a concomitant reduction in the energy and carbon intensity associated with their production. This program seeks to provide the technical underpinnings for a disruptive impact in the domestic light metals

manufacturing industry and accelerate the adoption of light metals in energy relevant applications. Achieving parity with steel would accelerate the use of lightweight metals in a variety of applications, enabling substantial energy consumption reductions. Other programs, such as the DOE's Vehicle Technology Program, are addressing additional challenges for the use of these light metals in vehicle technologies, notably improved methods for machining and joining to manufacture parts [13].

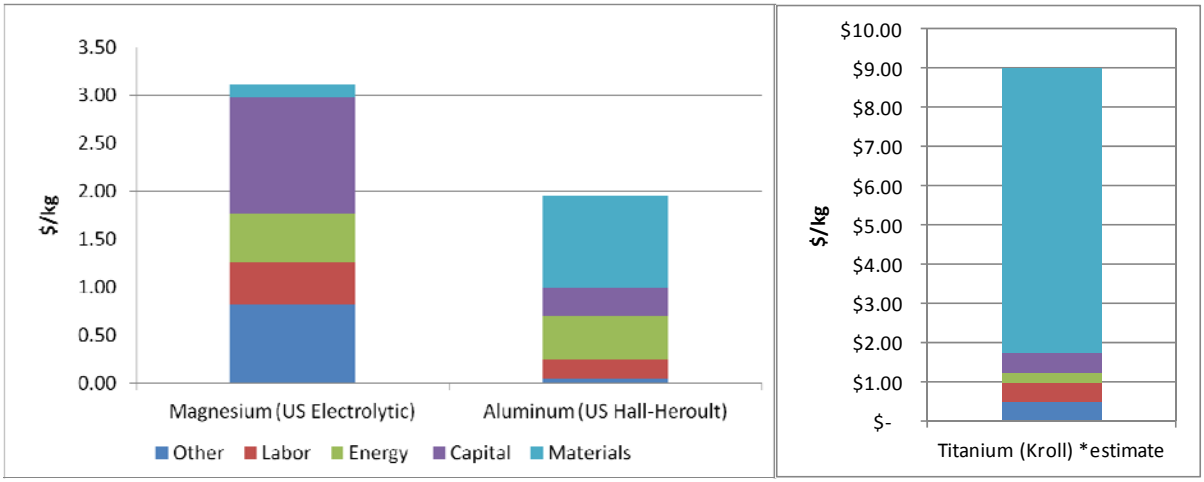

Figure 2: Cost profiles for U.S. magnesium, aluminum, and titanium production based on ARPA-E analysis using data from [4,6-8,10-11].

Light metals are superior to steels in strength-to-weight ratio, and it is therefore instructive to estimate how much light metal is required to replace steel in a structure. Specifically, a material substitution in a fabricated component of given bending strength, should have material thickness ratios (assuming identical cross sectional area) [14],

$$\frac{t_1}{t_2} = \sqrt{\frac{S_2}{S_1}} \tag{1}$$

where *t* is the part thickness, S is the yield strength of the material, and subscripts 1 and 2 denote materials 1 and 2. In order for the components made from materials 1 and 2 to have the identical cost and same embedded energy and emissions associated with material production, the following scaling relationships apply,

$$\frac{C_2}{C_1} = \frac{E_2}{E_1} = \frac{\chi_2}{\chi_1} = \sqrt{\frac{\rho_1 SR_2}{\rho_2 SR_1}} \tag{2}$$

where C is the cost intensity ($/kg), E is the process energy intensity (kWh/kg), χ is the CO_2 emissions intensity ($kgCO_2/kg$), ρ is the density, and SR is the strength-to-weight ratio. Table 3 summarizes the cost, energy, and emissions intensities for aluminum and magnesium that

would give parity to parts made from steel and for those required for titanium to reach parity with stainless steel. **The steel equivalent cost, energy, and emission intensities for the light metals provide benchmark performance targets for light metal production.** These are the basis for the establishment of the cost targets for Al, Mg, and Ti described in Section I.E.

Table 3: Energy, emissions, and cost requirements for parity with steel and stainless steel (current values taken from Tables 1 and 2).

	Aluminum		Magnesium		Titanium	
	Current	Steel Parity	Current	Steel Parity	Current	S.S. Parity
Energy (kWh/kg)	56	20.2	43.6	27.3	100	35
Emissions ($kgCO_2/kg$)	22	7.3	6.9	9.8	36	11.3
Cost ($/kg)	2.00	1.47	3.31	1.98	9.00	4.01

a. Aluminum

Aluminum is found in many commercial structures, consumer products, and parts. The largest markets for aluminum are transportation (34%), packaging (26%), building and construction (12%), electrical (9%), machinery (8%), and consumer durables (7%) [1]. The breadth of applications is due to the low cost of aluminum relative to other light metals and its excellent strength-to-weight ratio, corrosion resistance, thermal and electrical conductivity, and reflectivity. Aluminum demand is still expected to grow significantly due to vehicle lightweighting [15], but without the introduction of disruptive light metal technologies the supply will likely not be domestic. In 2009 shipments of aluminum to the U.S. auto industry totaled 1.9 Mtons and are expected to grow to 2.5 Mtons by 2035 as a result of the need for vehicle lightweighting [16].

The industry-standard for aluminum production is the Bayer process for refining bauxite to alumina followed by the Hall-Heroult process for the smelting of alumina to aluminum. Over 57% of the total energy is consumed by this 100-year-old second step [17]; additionally it is an electrolytic process that consumes carbon anodes and contributes to significant CO_2 emissions. The inefficiencies and environmental impact of the Hall-Heroult process continue to be addressed, but presently only 0.2% per year energy reduction has been realized [18], and occupational hazards for pot room workers persist [19].

The annual world production of aluminum is approximately 45 Mtons, requiring 8.2 quadrillion BTUs (quads) of energy. Comparatively, the U.S. annual production is about 2.0 Mtons, requiring an energy input of 0.4 quads [1,17]. Over the past two decades, the trend of domestic production of primary aluminum has been downward [1]. In 2012, the U.S. market share of world aluminum production was approximately 5% of global demand, down from 11%

a decade ago and 20% two decades ago. The U.S. annual demand for aluminum is approximately 4.5 Mtons and this demand is met by both primary and secondary (recycled) production; however, 20% of primary aluminum is imported in order to meet this demand [1].

b. Magnesium

Of the structural metals, magnesium has the highest strength-to-weight ratio. The majority of use, 41%, is for alloying with aluminum to improve its strength, ductility, and corrosion resistance. 32% is for die casting applications, such as automotive components, power tools, cell phone handsets, notebook computers, and others. 13% is for steel desulphurization, and the remaining 14% is for other uses in chemical processing, such as the extraction of titanium from rutile [6]. The U.S. demand in 2011 for magnesium was approximately 0.059 Mtons [1]. Of that total, 0.045 Mtons was produced domestically [20]. U.S. Magnesium LLC is the sole bulk producer of domestic magnesium, with only 1 electrolytic plant remaining (in Utah). China is currently the largest producer of magnesium worldwide with an output of 0.64 Mtons in 2012 [1].

Chinese magnesium is produced in batch using the thermochemical Pidgeon process, which is the reaction of ferrosilicon (FeSi) with dolomite (MgO). The energy requirements and CO_2 emissions of the Pidgeon process for Magnesium are both very high; 102 kWh/kg and 37 $kgCO_2/kg$, respectively [21]. In comparison, domestic magnesium production is an electrolytic process that requires approximately 43.6 kWh/kg and has emissions of 6.9 $kgCO_2/kg$ [22]. Its total capacity is 0.045 Mtons/yr. The cost of producing Chinese-Pidgeon magnesium is $2.50/kg. The U.S. Magnesium LLC cost, using a more environmentally sound approach, is approximately $3.31/kg [7].

c. Titanium

Titanium is one of only a few metals that have excellent native strength (strength-to-weight ratio), ductility, toughness, and superior corrosion resistance. Similar to magnesium, titanium demand has historically been limited by the high cost associated with the high processing energy. The majority of domestic use, 50%, is for industrial equipment, 35% is for commercial aerospace, 8% is for military aerospace, and the remaining 5% is used in other markets [23]. The worldwide production of titanium is 0.15 Mtons in 2011 with domestic production being 0.018 Mtons [1]. The U.S. annual demand for titanium is approximately 0.05 Mtons, and thus approximately 64% of titanium used for domestic consumption is imported [1]. The demand for titanium in the aerospace sector is expected to grow substantially due to the trend toward aircraft lightweighting [3]. Also, due to its excellent radiation absorption characteristics and corrosion resistance, titanium is extensively used in the nuclear industry [24]. As with the other metals, domestic production of primary titanium is on the decline, and the current domestic annual production is approximately half of what it was during the 1990s.

There are various commercial production processes for titanium. The most widely used are batch processes where titanium dioxide is chlorinated to produce titanium tetrachloride, which is in turn reduced with magnesium (Kroll process) or sodium (Hunter process) to titanium sponge. An energy input of 0.1 quads is required to produce the 0.15 Mtons of global titanium

and 0.01 quads for the 0.018 Mtons of domestic production [1,17]. A significant fraction of the materials cost in producing Ti (Figure 2) is associated with the cost of Mg for reduction via the Kroll process.

2. Need for Transformative and Disruptive Technologies in Light Metals Production

Figure 3 shows U.S. and global aluminum production and the percent of primary aluminum imported from the 1970s through 2011. There are two trends that raise concern. The first is that U.S. domestic production of aluminum is steadily on the decline while global production is rapidly rising. The second is that from the early 1990s through 2007 the percent of primary aluminum imported has been steadily on the rise and peaked in 2007 at 40%. Menzie et al. [25] project that by 2025 the global demand for aluminum will more than double, to 120 Mtons/yr, requiring at least an additional 8.7 quads of energy unless disruptive technologies are introduced.

The magnesium and titanium markets are considerably more volatile than that for aluminum but with similar trends. By 2011 64% of titanium was imported to meet domestic demand, and 30% was imported for magnesium.

Due to the energy intensive nature of light metals, importing these metals is equivalent to importing embedded energy, which runs counter to the U.S. goal of reducing energy imports. For example, the embedded energy in imported light metal amounted to 0.2 quads in 2012 and 0.4 quads in 2007. The technologies emerging from this program, which will place light metals on performance/cost parity with steel and stainless steel while significantly decreasing the energy and emissions from their processing, can reduce overall emissions and eliminate the importation of embedded energy. Moreover, these technologies can enable the U.S. to become a significant supplier of light metals to the world markets in order to meet increasing demand.

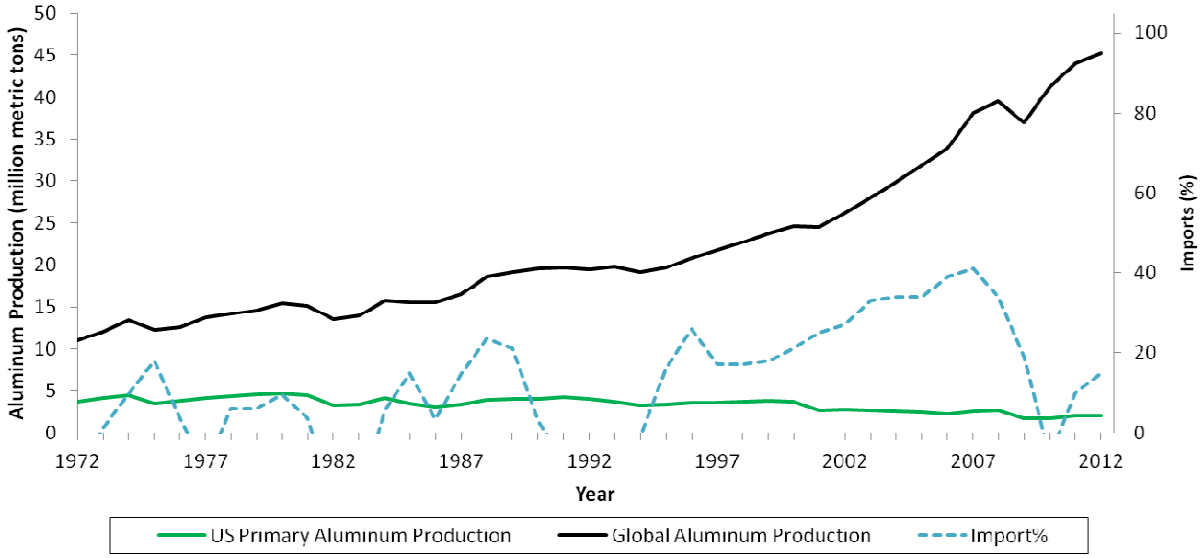

Figure 3: Aluminum production (US and global) and percent of primary aluminum imported from the 1970s through 2012.

2.1 Achieving Intended Energy Savings through Vehicle Lightweighting

The significant trend to manufacture lighter ground and air vehicles is motivated by consuming considerably less energy over the vehicle lifetime. The accelerated focus toward lightweighting ground vehicles is motivated by the aggressive 2025 Corporate Average Fuel Economy (CAFE) standards for cars and light-duty trucks set forth by the U.S. Department of Transportation (DOT) and the U.S. Environmental Protection Agency (EPA) in August 2012. These new standards mandate an increase in fleet fuel economy to 55 mpg by 2025 and build from previous standards requiring fleet fuel economy of 35 mpg by 2016.

The 55 mpg fleet standard cannot be met solely by improvements in the powertrain; radical new strategies and vehicle design will be required. Various groups have assessed the options for meeting these new requirements, but any viable scenario requires a 20-40% reduction in vehicle weight [2]. The DOE Vehicle Technologies Program sets a goal of a 50% weight reduction in passenger-vehicle body and chassis systems [13]. As a result, auto manufacturers are preparing to make use of light metals, especially aluminum/magnesium alloys, given their excellent strength-to-weight ratios. These light metals would replace heavier steel, which has been the metal of choice in automobiles to date.

Similarly, aircraft manufacturers are aggressively moving to deliver lightweight aircraft. For example, the new Boeing 787 aircraft is 20% lighter than the 767 model it is designed to replace [3]. A significant amount of carbon fiber is used to construct the aircraft, but the large galvanic potential between aluminum and carbon fiber can result in aluminum corrosion. Titanium, a high strength alternative structural material with superb ability to resist corrosion is therefore used. The aircraft industry anticipates that future lightweight aircraft will make expanded use of titanium [26] for the aircraft frame; this expansion can clearly be accelerated by reduction of domestic process energy intensity and therefore cost.

Lightweighting of both ground and air vehicles will lead to significant fuel energy savings. An ARPA-E analysis shows that if the entire ground fleet on the road in 2012 had all of its steel replaced with lighter weight aluminum or magnesium, approximately 2.5 or 3.2 quads of fuel energy could be saved per year, respectively. However, offsetting these savings is the enormous amount of energy required to produce aluminum and magnesium compared with steel, which means that approximately 80% of the net energy savings from lightweighting is lost (assumes a ten-year vehicle life). A similar offset exists for the use of titanium in air vehicles; the embedded energy in producing titanium is about 10% of the fuel energy savings over the lifetime of the aircraft (assumes a 20-year life). By meeting the steel equivalent energy intensity benchmarks shown in Table 3, the fleet of lightweight vehicles could realize the 2.5 to 3.2 quads/yr energy savings at the same cost as using steel, and start saving fuel on day 1 of use, rather than needing to make up for an energy debt embedded in the light metal(s). Such a

shift toward lightweight vehicle production and usage will enable a transformational shift in fleet fuel economy.

2.2 Scrap Metal Recycling to Enable Energy Savings

Recovery and recycling of light metals has always been a way to make gains in life-cycle production energy savings and to relieve raw ore production stresses. This is increasingly important in light of the expected 2025 global aluminum demand of 120 Mtons/yr and the domestic focus on vehicle lightweighting. After initial production ramp-up to meet new demand followed by the retirement of fleets, recycling will have even greater potential to meet replacement demand and could significantly reduce the required energy and cost to produce the vehicles. This future stands in stark contrast to the status quo in which the U.S. ships most of its metal scrap overseas.

The metal recycling process begins with scrapping automobiles, trailers, white goods (dishwashers, refrigerators, etc.), and metals recovered from municipal waste-to-energy plants. These items are first directed to a large hammermill-type shredder in which they are reduced to fist-size chunks of metal and copious amounts of non-metal (glass, plastic, foam, rubber, paper, etc.). Once shredded, air separation is employed to remove the lightest of the non-metal materials. Large magnets are then used to extract the ferrous-based materials (the majority of the metal fraction), which are then shipped to steel mills. The remaining material is comprised of non-ferrous metals and some non-metals (rock, glass, plastic, and wood) and is referred to as non-ferrous concentrate (NFC); also known as "Zorba". The Zorba fraction can be further “improved” by a combination of sizing, screening, and eddy-current or inductive-coil separators to reject the unwanted non-metals.

Most U.S. Zorba (as much as 50-75% by weight or 0.95-1.4 Mtons/yr) is shipped overseas, typically to China or India. Their low cost labor is very effective at hand sorting the different aluminum grades, along with the other metals [27]; neither the U.S. labor market or existing sorting technologies can match this. After being manually sorted abroad, the scrap metal is manufactured into parts. Only a small fraction of this metal returns to the U.S. as finished products, such as automobile engines; typically domestic manufacturers are forced to use more energy intensive primary light metal. The embedded energy in the scrap metal currently being shipped overseas is approximately 0.3 quads, while the embedded energy in imported metals varies from approximately 0.2-0.4 quads.

However, for cases when the market conditions are favorable in the U.S., the Zorba may undergo further domestic processing by sink-floatation or by X-ray transmission in which it is separated into light and heavy fractions. The light fraction is comprised of aluminum- and magnesium-based alloys called "Twitch". The heavy fraction is comprised of zinc, copper, brass, bronze, or stainless steel, predominantly known as "Zebra". Thus, Zorba equals Twitch plus Zebra. 80-85% of Zorba is the light metal Twitch.

Twitch is comprised of 1) a high-grade aluminum/magnesium alloy which has a low copper and iron content and 2) a low grade aluminum/magnesium alloy that has a higher iron and copper content. The value of Twitch can be significantly upgraded by separating out the high grade

aluminum/magnesium alloy. Economical advanced sorting technologies would significantly increase the value of Twitch and enable the domestic recycling of aluminum/magnesium alloy, thus reducing the domestic demand for more energy intensive primary metal.

Light metal demand for vehicle lightweighting will increase, which positively impacts the national goal of energy independence. However, with present U.S. production/importing/exporting patterns and variable energy content for different processes across the globe, the U.S. is effectively importing embedded energy via primary metal (as noted above) and exporting energy in low cost scrap. These outcomes diminish progress towards energy independence. The approach described here to reduce the energy intensity of primary light metal production and to enable high accuracy sorting/recycled light metals production technologies will enable vehicle lightweighting to be a more effective mechanism in moving toward overall energy independence.

C. PROGRAM OBJECTIVES

The previous sections described the impact of new processing and recycling technologies in reducing energy consumption and greenhouse gas emissions while lowering the market cost of domestically produced light metals. The existing bulk production processes for aluminum (Bayer and Hall-Heroult), magnesium (Pidgeon), and titanium (Kroll) have been in industrial practice for many decades. These processes are mature on the learning curve, and their further advancement to provide the cost, energy, and emissions intensity benchmarks, shown in Table 3, do not appear to be on the horizon. Therefore, new pathways for light metal processing and the management of energy throughout them need to be considered. Some alternative approaches that are potentially disruptive to the current practice for light metal processing are now presented as possible avenues for research and development: chemical pathways, energy inputs, heat-recovery/energy-storage/thermal-management, alternative ore feedstocks, and advanced sorting for recycling. These are not meant to be prescriptive, nor should they limit the response to this FOA. (See Section I.D for areas of interest and I.F for areas specifically not of interest).

1. Chemical Pathways

With current technologies, thermochemical reduction of metal oxide to metal typically requires lower capital cost than the comparable electrochemical approach, although the electrochemical approach tends to be more energy efficient. One thermochemical route to light metals production with potentially lower cost, lower energy, and lower emissions is carbothermic reduction. A metal oxide and carbon compound flow through a high temperature thermochemical reactor and reduced metal and carbon monoxide or Syngas exit the reactor under ideal conditions. When methane is used as a feedstock to reduce metal, Syngas is a possible by-product; thus an inherent advantage of carbothermic processing is that the energy used to produce metal also yields another value commodity stream which can help offset the cost of metal production. Carbothermic reforming of metals faces very challenging technical issues, including: thermodynamically unfavorable reactions, reactions that occur only at very

high temperature and/or low pressure, oxide back reaction and carbide formation, material compatibility issues at high temperature, separation of the product gases, and high-grade heat capture and utilization. Thoughtful consideration of equilibrium thermodynamics, reaction kinetics, and material compatibility may lead to innovative metal reactor concepts. A very useful tool to understand the thermodynamic constraints on the oxidation and reduction of metals is the Ellingham diagram [28]. Diagnostic tools to further the fundamental understanding of reaction pathways include high temperature XRD, mass spectroscopy, thermogravimetry, scanning tunneling microscopy, Raman spectroscopy, among others.

An interesting electrochemical pathway to light metal production is the use of a conducting solid oxide membrane, such as yttria stabilized zirconia, as an anode. The advantage of this approach is that oxygen passes through the porous zirconia anode and is isolated from the metal; therefore back reactions with oxygen are eliminated. An overview of the method is provided by Pal and Powell [29]. While this method has been successfully implemented for the production of magnesium, challenges remain. These include zirconia anode stability in contact with a high temperature electrolyte, preventing thermal shock and cracking of the anode, obtaining sufficient current density with minimal potential drop across the zirconia anode, and cost effective scale-up to production capacity.

Both the carbothermic thermochemical and zirconia anode electrochemical approaches allow for continuous processing as opposed to batch processing (current practice). The advantages of continuous processing are larger throughput per unit volume and amenability to automation, both of which potentially lead to cost reduction. These are just two of many possible alternative chemical routes to light metals production. More generally, *ARPA-E seeks chemical pathways that allow for continuous processing with a variety of energy input options*.

2. Energy Inputs

While a variety of energy inputs could be used for the reduction of metal oxides, the reaction temperatures are sufficiently high, typically greater than 1400°C, that a significant amount of electrical power or concentrated solar power would be required to reach them. The drawback in using grid power is that during peak hours, the cost is considerably higher than that at off-peak. It would be advantageous to have a flexible production process that can be taken off grid during peak hours, or as needed. This can be accomplished by shutting down the metal production process during peak hours or making use of high temperature thermal energy storage to produce on-site power that can be fed back into the process during peak hours. As more variable renewable energy sources are integrated into the grid, flexible light metal processing with integrated heat storage and recuperation could be used as a load leveling tool.

In addition, flexible processing technologies incorporating heat storage and recovery can also enable renewable energy inputs to be integrated *directly* into the process. For example, light metal production processes designed to operate with the heat from concentrated solar power will need to incorporate variable operation, thermal energy storage, or both. Figure 4 illustrates a conceptual carbothermic metal production process operating with a hybrid solar/grid energy

input. Operating under such a scenario requires very complex thermal management, energy storage, and control. It is likely that there is an economic advantage to sustain metal production for as long as possible without shutting down the operation. Grid power and/or high temperature thermal energy storage technologies will enable such operation. As such, *ARPA-E seeks technologies to that are compatible with variable energy sources*.

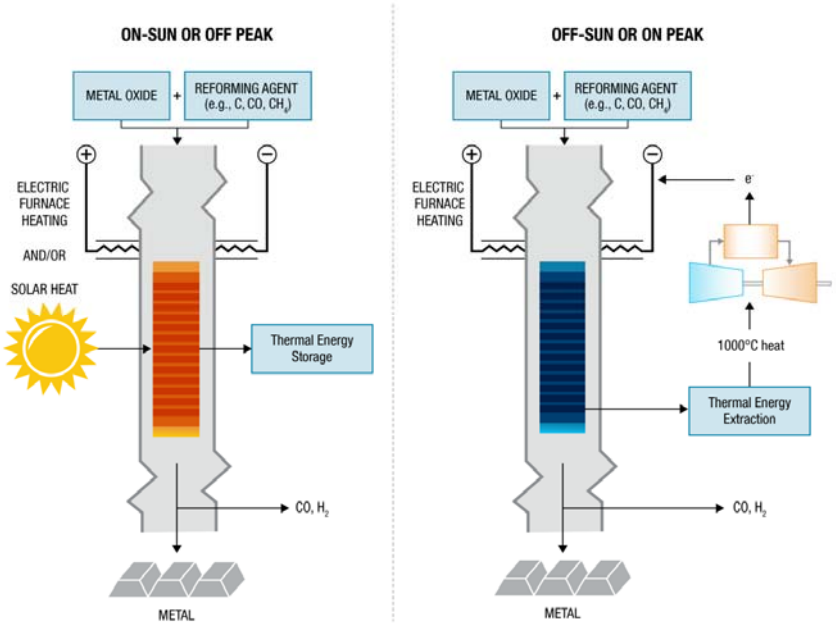

Figure 4: Conceptual carbothermic reactor operating with a hybrid solar/grid energy input.

3. Heat Recovery, Energy Storage, and Thermal Management

The thermal energy losses in conventional light metal processing facilities are substantial and are the origin of the very low energy efficiencies. Processing facilities were not designed with energy efficiency as a goal and are very difficult to retrofit for heat recovery. For example, the Hall-Heroult electrochemical cell has built in heat loss to preserve a thin layer of solid electrolyte that protects the cell from molten cryolyte. The hot off-gas contains particulates and hydrogen fluoride (HF) which are corrosive to typical heat exchangers. The Bayer process also loses substantial thermal energy contained in hot exhaust gases from the calciner. Such losses are on the order of megawatts per facility. In conceiving innovative and transformative light metal production processes, heat recovery and thermal management should be an overarching goal as they will significantly impact the process energy efficiency and therefore cost and emissions.

Thermodynamics dictate that high temperature heat has considerably higher value than that captured at low temperature because it enables more economical electrical power production. Molten metal is an excellent high temperature thermal energy storage medium as it stores both sensible and latent heat; however, a commercial technology to recover it does not currently exist. This is related to the fact that high temperature molten metal is highly reactive. Highly

specialized materials and inert gas purge are required for handling, and pumping technologies typically needed for thermal convective transport are not available. The development of a molten metal high temperature thermal storage and heat recovery technology would indeed be transformative for light metal production. *ARPA-E seeks innovative concepts in heat recovery, energy storage, and thermal management to be integrated with light metals processing*.

4. Alternative Ore Feedstocks

Using aluminum as an example, production begins with conversion of Bauxite ore to alumina. The domestic reserves of Bauxite are very low compared with other mineral rich nations, and today the US relies on alumina extracted from Bauxite mined in Jamaica, Guinea, and Brazil. The imported alumina comprises approximately one quarter of the cost to produce aluminum. While the known domestic reserves of Bauxite are very low, there are substantial reserves of an alternative source of alumina, anorthosite, which contains approximately fifty percent silica, thirty percent alumina, and twenty percent calcium oxide [30]. It is estimated that the U.S. has anorthosite reserves on the order of 600 billion tons [31]. A domestic alumina production process from anorthosite at less than $0.50/kg provides a potential path to increased domestic production of aluminum and could be disruptive. *ARPA-E seeks new processes that are able to cost-effectively take advantage of domestically available and abundant ore feedstocks for each of the light metals of interest*.

5. Advanced Sorting Technology for Scrap Metal Recycling

As previously mentioned, the aluminum/magnesium alloy scrap product, Zorba, can be significantly upgraded by separating out the high grade aluminum/magnesium alloy. Economical advanced sorting technologies would significantly increase the value of Zorba and enable the domestic recycling of scrap aluminum/magnesium alloy. The extraction of Twitch from Zorba can be accomplished with inexpensive sink float technology. The selection of high grade aluminum/magnesium alloy from Twitch requires precise and rapid identification of every piece that is transported on the conveyor. The identification of aluminum/magnesium alloys using x-ray transmission (XRT) spectroscopy is a possible solution. However, the intrinsic limitations of an XRT sensor leads to a spectra overlap among similar alloys, which would make alloy separation difficult. A more effective approach could employ x-ray fluorescence (XRF) spectroscopy, although at a higher cost, and economic viability would need to be investigated.

Another possible solution is to tag the alloy with trace amounts of compounds that are easily identifiable, distinguishable, and do not change the properties of the alloy. As an example, doping of building construction materials with barium sulfate, manganese dioxide, or mixtures are used as tags . XRF is used to identify the concentration of the doping material and verify that the construction material is not a lower grade imitation. A less costly solution for metals may be to use infrared fluorescence spectroscopy, with a very small concentration of rare earth complexes to serve as tags. A concern is whether or not the tag concentrations will be diluted and altered during the re-alloying process.

These represent a few alternative technologies to the sorting of the abundant production of domestic scrap light metal. Many others could be imagined and *ARPA-E seeks transformative*

ideas that will lead to rapid, high precision, and automated sorting technologies for Al, Mg, and Ti alloy scrap.

D. TECHNICAL CATEGORIES OF INTEREST

The objective of this program is to support the development of transformational new technologies in processing or recycling that enable lightweight metals (aluminum, magnesium and titanium) to be not only cost competitive with the incumbent structural metals (steel and stainless steel), but also with a concomitant reduction in the energy and carbon intensity associated with their production from primary or secondary sources. Accordingly, two categories are of interest:

- **Category 1. Transformative routes to produce primary Al, Mg, and/or Ti (powder, including Titanium Hydride powder), that provide significant reductions to cost, energy, and emissions.**

  Preference will be given to concepts that allow for one or more of the following:
  a. Variable energy inputs
  b. Renewable energy inputs
  c. High temperature heat capture
  d. High temperature thermal storage
  e. Utilization of domestically abundant ores

Integrated system approaches accomplishing one or more of these objectives (a-e) are of interest, but innovative concepts focused on energy intensive and/or high cost stages of the production process will also be considered.

- **Category 2. Transformative technologies that enable rapid, precision, and automated sorting of Al, Mg, and Ti alloy scrap.**
  Integrated sorting technologies and high efficiency secondary light metal production processes that enable finished product from recycled scrap are also of interest.

- **Areas that are discouraged**
  Routine or incremental improvements to the Hall-Heroult, Pidgeon, and Kroll processes are discouraged. Transformative improvements in these processes that can be demonstrated to meet the program metrics will be considered on a case-by-case basis.

- **Areas not of interest**
  - Melting technologies
  - Casting technologies
  - Power generation technologies (available technologies for power generation will be assumed, but not funded by ARPA-E through this program)
  - Processes that are not amenable to start-up and shut-down cycles

- Recycling/secondary production technologies that only offer energy efficiency advantages without also incorporating advanced sorting technologies
- Solid oxide membrane electrochemical processes for magnesium

E. TECHNICAL PERFORMANCE TARGETS

ARPA-E sets aggressive technical and economic targets in order to encourage applicants to propose transformative solutions that require creative alternatives, enabled by an expanded science base, to the current state of technology. Only those technologies that have a well-justified potential to approach, meet or exceed the technical and economic performance targets will be considered for funding.

ARPA-E recognizes that laboratory scale prototype technologies may not be able to meet the performance targets without projection to operation at a production scale. In such cases, applicants must submit a rigorous analysis that demonstrates how laboratory prototype performance can be extrapolated to the production scale and meet the performance targets. All proposed technology concepts must demonstrate that they can accommodate sufficient throughput to scale to industrial production.

1. Primary Metal Production

Processing Energy

For the purpose of this funding opportunity, the processing energy intensity is defined as,

$$E = \frac{E_{in} - E_{rec} - E_{ren}}{M_{metal}}$$

where E_{in} is the sum of the energy inputs to the system, E_{rec} is energy recovered and reused in the system, E_{ren} is renewable energy that is directly integrated in and used by the system, and M_{metal} is the mass of metal discharging the system. Renewable energy that is delivered through the grid is not counted.

Note that this definition of energy intensity incentivizes the use of heat recovery and renewable energy within the system – a radical departure from current technology. The process energy efficiency targets for Al, Mg, and Ti are shown in the table below and are equivalent to the benchmarks for parity with steel and stainless steel.

Metal	Al	Mg	Ti
Target E	**≤20 kWh/kg**	**≤27 kWh/kg**	**≤35 kWh/kg**
Industrial Current (Tables 1 and 2)	56 kWh/kg	44 kWh/kg (U.S Mag.) 102 kWh/kg (Pidg.)	100 kWh/kg

CO_2 Emissions

For the purpose of this funding opportunity, the CO_2 emissions are defined as,

$$\chi_{CO2} = \frac{M_{CO2}}{M_{metal}}$$

where M_{CO2} is the mass of CO_2 discharging the system. It is noted that CO discharging the system which is collected and used toward Syngas production or some other end product, is not counted toward emissions. However, should CO be combusted and energy put back into the system, the resulting CO_2 from combustion will be counted toward emissions. The CO_2 emissions targets for Al, Mg, and Ti are shown in the table below.

Metal	Al	Mg	Ti
Target χ_{CO2}	**≤7 $kgCO_2/kg$**	**≤10 $kgCO_2/kg$**	**≤11 $kgCO_2/kg$**
Industrial Current (Tables 1 and 2)	22 $kgCO_2/kg$	7 $kgCO_2/kg$ (U.S. Mag.) 37 $kgCO_2/kg$ (Pidg.)	36 $kgCO_2/kg$

Cost

Applicants must provide an estimate of the cost profile for the proposed technology, similar to those shown for aluminum, magnesium, and titanium in Figure 2. This estimate must include an explanation of how the new technology innovation will reduce the current cost profile for the relevant metal(s) such that the projected production costs will meet the end of project target(s). Proposed systems/processes that produce a value stream in addition to the metal (for example Syngas) may compute the value of

the additional product and subtract it from the cost. For proposed concepts where cost targets will not be met within the period of performance, applicants must provide a thorough analysis detailing how the target cost will be approached and the timeframe for doing so. The cost targets for Al, Mg, and Ti are shown in the table below.

Metal	Al	Mg	Ti (powder) or Ti-hydride (powder)
Target Cost	**≤$1.50/kg**	**≤$2.00/kg**	**≤$4.00/kg**
Industrial Current (U.S. Tables 1 and 2)	$2.00/kg	$3.31/kg (U.S. Mag.) $2.50/kg (China Pidg.)	$9.00/kg

II. Recycling

Sorting must be done at a rate that can scale to a production rate of at least 4 Tons/hr. The sorting technology should be able to make a decision on the type of alloy for every piece of scrap metal passing through the sorter. The sorting system should achieve a sorting success rate of 99% or greater (the success rate is defined such that for every 100 pieces of scrap that pass through the sorter, on average, the alloy composition of 99 pieces should be correctly identified). Sorting should be done at a total cost of $0.04 per kg of scrap or less.

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 parameters specified in the FOA, including but not limited to:
  - Non-enzymatic routes to produce syngas
  - Fuel synthesis pathways that use syngas or CO_2 and H_2 as starting reactants
  - Purely non-biological approaches for methane conversion to liquid fuels
  - Production of hydrocarbon compounds that are neither fuel molecules or fuel molecule precursors, or exist primarily in the gas phase at STP
  - Biological approaches that rely on the accumulation of cell biomass as an intermediate to fuel production.

- 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).
- Applications that are not technically distinct from existing funded activities supported elsewhere, including within the Department of Energy (examples include but are not limited to Energy Efficiency and Renewable Energy in both the Vehicle Technologies Program and the Advanced Manufacturing Office) or by other federal agencies (examples include but are not limited to the Department of Defense and the National Science Foundation).

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II. AWARD INFORMATION

A. AWARD OVERVIEW

ARPA-E expects to make approximately ~~$20~~ $30 million available for new awards under this FOA, subject to the availability of appropriated funds. ARPA-E anticipates making approximately 8-12 awards under this FOA. ARPA-E may issue one, multiple, or no awards.

Individual awards may vary between approximately $250,000 and $10 million. ARPA-E will provide support at the upper ranges only for applications with significant technology risk, aggressive timetables, and careful management and mitigation of the associated risks.

The period of performance for funding agreements may not exceed 36 months. ARPA-E expects the start date for funding agreements to be ~~10/01/2013~~ 11/01/2013 or as negotiated.

ARPA-E will accept only new applications under this FOA. Applicants may not seek renewal or supplementation of their existing awards through this FOA.

ARPA-E may issue awards in one or both of the following funding categories: "Proof-of-Concept Seedling Project" and "Technology Development Project."

- **Proof-of-Concept Seedling Project:** Proof-of-Concept Seedlings are projects which range between $250,000 and $~~10~~1 million and have a period of performance of no more than a year. If both of these criteria are not met, the project is a Technology Development Project. Seedling projects typically focus on early-stage, proof-of-concept level R&D efforts. Applicants should submit evidence of an idea, described in sufficient technical detail to allow reviewers to meaningfully evaluate the proposed project. ARPA-E may issue approximately 2-4 awards in this category, with an average award amount of $500,000.

- **Technology Development Project:** Awards that either range between $1 million and $10 million, have a period of performance longer than one year, or both are Technology Development Projects. These projects typically focus on early-stage prototypes of various technology concepts for which some kind of initial proof-of-concept component demonstration already exists. Applicants should submit concrete data that supports the success of the proposed project. ARPA-E may issue approximately 6-8 awards in this category, with an average award amount of $3 million.

ARPA-E may establish more than one budget period for each award and fund only the initial budget period(s). Applicants are not guaranteed funding beyond the initial budget period(s).

Before the expiration of the initial budget period(s), ARPA-E may perform a down-select among different recipients and provide additional funding only to a subset of recipients.

B. ARPA-E FUNDING AGREEMENTS

Through Cooperative Agreements, Technology Investment Agreements, and similar agreements, ARPA-E provides financial and other support to projects that have the potential to realize ARPA-E's statutory mission. ARPA-E does not use such agreements to acquire property or services for the direct benefit or use of the U.S. Government.

Congress directed ARPA-E to "establish and monitor project milestones, initiate research projects quickly, and just as quickly terminate or restructure projects if such milestones are not achieved."[2] Accordingly, ARPA-E has substantial involvement in the direction of every project, as described in Section II.C below.

1. COOPERATIVE AGREEMENTS

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients.[3]

Cooperative Agreements involve the provision of financial or other support to accomplish a public purpose of support or stimulation authorized by Federal statute. Under Cooperative Agreements, the Government and Prime Recipients share responsibility for the direction of projects.

ARPA-E encourages Prime Recipients to review the Model Cooperative Agreement, which is available at http://arpa-e.energy.gov/?q=project-guidance/award.

2. FUNDING AGREEMENTS WITH FFRDCS, GOGOS, AND FEDERAL INSTRUMENTALITIES[4]

Any Federally Funded Research and Development Centers (FFRDC) involved as a member of a Project Team must complete the "FFRDC Authorization" and "Field Work Proposal" section of the Business Assurances Form, which is submitted with the Applicant's Full Application.

When a FFRDC is the *lead organization* for a Project Team, ARPA-E executes a funding agreement directly with the FFRDC and a single, separate Cooperative Agreement with the rest of the Project Team. Notwithstanding the use of multiple agreements, the FFRDC is the lead

[2] U.S. Congress, Conference Report to accompany the 21st Century Competitiveness Act of 2007, H. Rpt. 110-289 at 171-172 (Aug. 1, 2007).
[3] The Prime Recipient is the signatory to the funding agreement with ARPA-E.
[4] DOE/NNSA GOGOs are not eligible to apply for funding, as described in Section III.A of the FOA.

organization for the entire project, including all work performed by the FFRDC and the rest of the Project Team.

When a FFRDC or non-DOE/NNSA GOGO is a *member* of a Project Team, ARPA-E executes a funding agreement directly with the FFRDC or non-DOE/NNSA GOGO and a single, separate Cooperative Agreement with the rest of the Project Team. Notwithstanding the use of multiple agreements, the Prime Recipient under the Cooperative Agreement is the lead organization for the entire project, including all work performed by the FFRDC or non-DOE/NNSA GOGO and the rest of the Project Team.

Funding agreements with DOE/NNSA FFRDCs take the form of Work Authorizations issued to DOE/NNSA FFRDCs through the DOE/NNSA Field Work Proposal system for work performed under Department of Energy Management & Operation Contracts. Funding agreements with non-DOE/NNSA FFRDCs, GOGOs, and Federal instrumentalities (e.g., Tennessee Valley Authority) generally take the form of Interagency Agreements. Any funding agreement with a FFRDC or non-DOE/NNSA GOGO will have substantially similar terms and conditions as ARPA-E's Model Cooperative Agreement (http://arpa-e.energy.gov/?q=project-guidance/award).

3. TECHNOLOGY INVESTMENT AGREEMENTS

ARPA-E may use its "other transactions" authority under the America COMPETES Reauthorization Act of 2010 or DOE's "other transactions" authority under the Energy Policy Act of 2005 to enter into Technology Investment Agreements (TIAs) with Prime Recipients. ARPA-E may negotiate a TIA when it determines that the use of a standard cooperative agreement, grant, or contract is not feasible or appropriate for a project.

A TIA is more flexible than a traditional financial assistance agreement. In using a TIA, ARPA-E may modify standard Government terms and conditions.

If Applicants are seeking to negotiate a TIA, they are required to include an explicit request in their Full Applications. Please refer to the Business Assurances Form for guidance on the content and form of the request.

In general, TIAs require a cost share of 50%. See Section III.B.2 of the FOA.

4. GRANTS

Although ARPA-E has the authority to provide financial support to Prime Recipients through Grants, ARPA-E generally does not fund projects through Grants. ARPA-E may fund a limited number of projects through Grants, as appropriate.

C. STATEMENT OF SUBSTANTIAL INVOLVEMENT

Generally, ARPA-E is substantially involved in the direction of projects (regardless of the type of funding agreement) from inception to completion. For the purposes of an ARPA-E project, substantial involvement means:

- ARPA-E does not limit its involvement to the administrative requirements of the ARPA-E funding agreement. Instead, ARPA-E has substantial involvement in the direction and redirection of the technical aspects of the project as a whole. Project teams must adhere to ARPA-E technical direction and comply with agency-specific and programmatic requirements.

- ARPA-E may intervene at any time to address the conduct or performance of project activities.

- During award negotiations, ARPA-E Program Directors establish an aggressive schedule of quantitative milestones and deliverables that must be met every quarter. Prime Recipients document the achievement of these milestones and deliverables in quarterly technical and financial progress reports, which are reviewed and evaluated by ARPA-E Program Directors (see Attachment 4 to ARPA-E's Model Cooperative Agreement, available at http://arpa-e.energy.gov/?q=project-guidance/award). ARPA-E Program Directors visit each Prime Recipient at least twice per year, and hold periodic meetings, conference calls, and webinars with Project Teams. ARPA-E Program Directors may modify or terminate projects that fail to achieve predetermined technical milestones and deliverables.

- ARPA-E reviews reimbursement requests for compliance with applicable Federal cost principles and Prime Recipients' cost share obligations.[5] Upon request, Prime Recipients are required to provide additional information and documentation to support claimed expenditures. Prime Recipients are required to comply with agency-specific and programmatic requirements. Please refer to Section VI.B.3-4 of the FOA for guidance on proof of cost share commitment and cost share reporting.

- ARPA-E works closely with Prime Recipients to facilitate and expedite the deployment of ARPA-E-funded technologies to market. ARPA-E works with other Government agencies and nonprofits to provide mentoring and networking

[5] To request reimbursement, Prime Recipients must submit: (1) a Standard Form (SF) 270 ("Request for Advance or Reimbursement"); (2) a "Reimbursement Request Spreadsheet," which must contain the information shown in Appendix B to Attachment 1 of ARPA-E's Model Cooperative Agreement (http://arpa-e.energy.gov/?q=project-guidance/award); and (3) supporting documentation, which may consist of summary information (e.g., printouts from internal financial systems) or detailed documentation (e.g., invoices on appropriate letterhead, time cards, travel vouchers). The supporting documentation must show the method by which the Prime Recipient calculated the total Federal share and non-Federal cost share.

opportunities for Prime Recipients. ARPA-E also organizes and sponsors events to educate Prime Recipients about key barriers to the deployment of their ARPA-E-funded technologies. In addition, ARPA-E establishes collaborations with private and public entities to provide continued support for the development and deployment of ARPA-E-funded technologies.

- ARPA-E may fund some projects on a fixed-obligation basis.

III. ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

1. INDIVIDUALS

U.S. citizens or permanent residents may apply for funding in their individual capacity as a Standalone Applicant,[6] as the lead for a Project Team,[7] or as a member of a Project Team.

2. DOMESTIC ENTITIES

For-profit entities, educational institutions, and nonprofits[8] that are incorporated in the United States, including U.S. territories, are eligible to apply for funding as a Standalone Applicant, as the lead organization for a Project Team, or as a member of a Project Team.

FFRDCs are eligible to apply for funding as the lead organization for a Project Team or as a member of a Project Team, but not as a Standalone Applicant.

DOE/NNSA GOGOs are not eligible to apply for funding.

Non-DOE/NNSA GOGOs are eligible to apply for funding as a member of a Project Team, but not as a Standalone Applicant or as the lead organization for a Project Team.

State and local government entities are eligible to apply for funding as a member of a Project Team, but not as a Standalone Applicant or as the lead organization for a Project Team.

Federal agencies and instrumentalities (other than DOE) are eligible to apply for funding as a member of a Project Team, but not as a Standalone Applicant or as the lead organization for a Project Team.

3. FOREIGN ENTITIES

Foreign entities, whether for-profit or otherwise, are eligible to apply for funding as Standalone Applicants, as the lead organization for a Project Team, or as a member of a Project Team. All work by foreign entities must be performed by subsidiaries or affiliates incorporated in the

[6] A Standalone Applicant is an Applicant that applies for funding on its own, not as part of a Project Team.
[7] The term "Project Team" is used to mean any entity with multiple players working collaboratively and could encompass anything from an existing organization to an ad hoc teaming arrangement. A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.
[8] Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995 are not eligible to apply for funding as a Prime Recipient or Subrecipient.

United States (including U.S. territories). The Applicant may request a waiver of this requirement in the Business Assurances Form, which is submitted with the Full Application. Please refer to the Business Assurances Form for guidance on the content and form of the request.

4. CONSORTIUM ENTITIES

Consortia, which may include domestic and foreign entities, must designate one member of the consortium as the consortium representative to the Project Team. The consortium representative must be incorporated in the United States. The eligibility of the consortium will be determined by reference to the eligibility of the consortium representative under Section III.A of the FOA. Each consortium must have an internal governance structure and a written set of internal rules. Upon request, the consortium entity must provide a written description of its internal governance structure and its internal rules to the DOE Contracting Officer (ARPA-E-CO@hq.doe.gov).

Unincorporated consortia must provide the Contracting Officer with a collaboration agreement, commonly referred to as the articles of collaboration, which sets out the rights and responsibilities of each consortium member. This agreement binds the individual consortium members together and should discuss, among other things, the consortium's:

- Management structure;
- Method of making payments to consortium members;
- Means of ensuring and overseeing members' efforts on the project;
- Provisions for members' cost sharing contributions; and
- Provisions for ownership and rights in intellectual property developed previously or under the agreement.

B. COST SHARING OR MATCHING[9]

Applicants are bound by the cost share proposed in their Full Applications. In the Business Assurances Form accompanying the Full Application, Applicants must provide written assurance of their cost share commitments. Please refer to the Business Assurances Form available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov) for additional guidance.

[9] Please refer to Section VI.B.3-4 of the FOA for guidance on cost share payments and reporting.

1. BASE COST SHARE REQUIREMENT

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients (see Section II.B.1 of the FOA). Under a Cooperative Agreement, the Prime Recipient must provide at least 20% of the Total Project Cost[10] as cost share, except as provided in Sections III.B.2 or III.B.3 below.[11]

2. INCREASED COST SHARE REQUIREMENT

Large businesses are strongly encouraged to provide more than 20% of the Total Project Cost as cost share. ARPA-E may consider the amount of cost share proposed by large businesses when selecting applications for award negotiations (see Section V.B.1 of the FOA).

The Prime Recipient may request the use of a Technology Investment Agreement (instead of a Cooperative Agreement) in the Business Assurances Form submitted with the Full Application (see Section II.B.3 of the FOA). Under a Technology Investment Agreement, the Prime Recipient must provide at least 50% of the Total Project Cost as cost share. ARPA-E may reduce this minimum cost share requirement, as appropriate.

3. REDUCED COST SHARE REQUIREMENT

ARPA-E has reduced the minimum cost share requirement for the following types of projects:

- A domestic educational institution or domestic nonprofit applying as a Standalone Applicant is required to provide at least 5% of the Total Project Cost as cost share.

- Project Teams composed exclusively of domestic educational institutions, domestic nonprofits, and/or FFRDCs are required to provide at least 5% of the Total Project Cost as cost share.

- Project Teams where domestic educational institutions, domestic nonprofits, and/or FFRDCs perform greater than or equal to 80%, but less than 100%, of the total work under the funding agreement (as measured by the Total Project Cost) are required to provide at least 10% of the Total Project Cost as cost share. However, any entity (such as a large business) receiving patent rights under a class waiver, or other patent waiver, that is part of a Project Team receiving this reduction must continue to meet the statutory minimum cost share requirement (20%) for its portion of the Total Project Cost.

[10] The Total Project Cost is the sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by GOGOs, FFRDCs, and GOCOs.
[11] Energy Policy Act of 2005, Pub.L. 109-58, sec. 988.

- Projects that do not meet any of the above criteria are subject to the minimum cost share requirements described in Sections III.B.1 and III.B.2 of the FOA.

4. LEGAL RESPONSIBILITY

Although the cost share requirement applies to the Project Team as a whole, the funding agreement makes the Prime Recipient legally responsible for paying the entire cost share. The Prime Recipient's cost share obligation is expressed in the funding agreement as a static amount in U.S. dollars (cost share amount) and as a percentage of the Total Project Cost (cost share percentage). If the funding agreement is terminated prior to the end of the project period, the Prime Recipient is required to contribute at least the cost share percentage of total expenditures incurred through the date of termination. ARPA-E requires all recipients to contribute cost share in proportion with each submitted invoice over the life of the program.

The Prime Recipient is solely responsible for managing cost share contributions by the Project Team and enforcing cost share obligations assumed by Project Team members in subawards or related agreements.

5. COST SHARE ALLOCATION

Each Project Team is free to determine how much each Project Team member will contribute towards the cost share requirement. The amount contributed by individual Project Team members may vary, as long as the cost share requirement for the project as a whole is met.

6. COST SHARE TYPES AND ALLOWABILITY

Every cost share contribution must be allowable under the applicable Federal cost principles, as described in Section IV.G.1 of the FOA.

Project Teams may provide cost share in the form of cash or in-kind contributions. Cash contributions may be provided by the Prime Recipient or Subrecipients. Allowable in-kind contributions include but are not limited to personnel costs, indirect costs, facilities and administrative costs, rental value of buildings or equipment, and the value of a service, other resource, or third party in-kind contribution. Project Teams may use funding or property received from state or local governments to meet the cost share requirement, so long as the funding or property was not provided to the state or local government by the Federal Government.

The Prime Recipient may not use the following sources to meet its cost share obligations:

- Revenues or royalties from the prospective operation of an activity beyond the project period;

- Proceeds from the prospective sale of an asset of an activity;
- Federal funding or property (e.g., Federal grants, equipment owned by the Federal Government); or
- Expenditures that were reimbursed under a separate Federal program.

In addition, Project Teams may not use independent research and development (IR&D) funds to meet their cost share obligations under cooperative agreements. However, Project Teams may use IR&D funds to meet their cost share obligations under Technology investment Agreements.

Project Teams may not use the same cash or in-kind contributions to meet cost share requirements for more than one project or program.

Cost share contributions must be specified in the project budget, verifiable from the Prime Recipient's records, and necessary and reasonable for proper and efficient accomplishment of the project. Every cost share contribution must be reviewed and approved in advance by the DOE Contracting Officer and incorporated into the project budget before the expenditures are incurred.

Applicants may wish to refer to 10 C.F.R. parts 600 and 603 for additional guidance on cost sharing, specifically 10 C.F.R. §§ 600.30, 600.123, 600.224, 600.313, and 603.525-555.

7. COST SHARE CONTRIBUTIONS BY FFRDCS AND GOGOS

Because FFRDCs and GOGOs are funded by the Federal Government, costs incurred by FFRDCs and GOGOs generally may not be used to meet the cost share requirement. FFRDCs may contribute cost share only if the contributions are paid directly from the contractor's Management Fee or a non-Federal source.

8. COST SHARE VERIFICATION

Applicants are required to provide written assurance of their proposed cost share contributions in their Full Applications. Please refer to the Business Assurances Form for guidance on the cost share information that must be included.

Upon selection for award negotiations, Applicants are required to provide additional information and documentation regarding their cost share contributions. Please refer to Section VI.B.3 of the FOA for guidance on the requisite cost share information and documentation.

C. OTHER

1. COMPLIANT CRITERIA

Concept Papers are deemed compliant if:

- The Applicant meets the eligibility requirements in Section III.A of the FOA;
- The Concept Paper complies with the content and form requirements in Section IV.C of the FOA; and
- The Applicant entered all required information, successfully uploaded all required documents, and clicked the "Submit" button in ARPA-E eXCHANGE by the deadline stated in the FOA.

ARPA-E will not review or consider noncompliant Concept Papers, including Concept Papers submitted through other means, Concept Papers submitted after the applicable deadline, and incomplete Concept Papers. A Concept Paper is incomplete if it does not include required information, such as the funding category (see Section II.A of the FOA). ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.

Full Applications are deemed compliant if:

- The Applicant submitted a compliant and responsive Concept Paper;
- The Applicant meets the eligibility requirements in Section III.A of the FOA;
- The Full Application complies with the content and form requirements in Section IV.D of the FOA; and
- The Applicant entered all required information, successfully uploaded all required documents, and clicked the "Submit" button in ARPA-E eXCHANGE by the deadline stated in the FOA.

ARPA-E will not review or consider noncompliant Full Applications, including Full Applications submitted through other means, Full Applications submitted after the applicable deadline, and incomplete Full Applications. A Full Application is incomplete if it does not include required information and documents, such as Forms SF-424 and 424A. ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.

Replies to Reviewer Comments are deemed compliant if:

- The Applicant successfully uploaded all required documents to ARPA-E eXCHANGE by the deadline stated in the FOA.

ARPA-E will not review or consider noncompliant Replies to Reviewer Comments, including Replies submitted through other means and Replies submitted after the applicable deadline. ARPA-E will not extend the submission deadline for Applicants that fail to submit required information due to server/connection congestion. ARPA-E will review and consider each compliant and responsive Full Application, even if no Reply is submitted or if the Reply is found to be noncompliant.

2. RESPONSIVENESS CRITERIA

ARPA-E performs a preliminary technical review of Concept Papers and Full Applications. Any "Applications Specifically Not of Interest," as described in Section I.G of the FOA, are deemed nonresponsive and are not reviewed or considered.

3. LIMITATION ON NUMBER OF APPLICATIONS

ARPA-E is not limiting the number of applications that may be submitted by Applicants. Applicants may submit more than one application to this FOA, provided that each application is scientifically distinct.

IV. APPLICATION AND SUBMISSION INFORMATION

A. APPLICATION PROCESS OVERVIEW

1. REGISTRATION IN ARPA-E eXCHANGE

The first step in applying to this FOA is registration in ARPA-E eXCHANGE, ARPA-E's online application portal. For detailed guidance on using ARPA-E eXCHANGE, please refer to Section IV.H.1 of the FOA and the "ARPA-E eXCHANGE User Guide" (https://arpa-e-foa.energy.gov/Manuals.aspx).

2. CONCEPT PAPERS

Applicants must submit a Concept Paper by the deadline stated in the FOA. Section IV.C of the FOA provides instructions on submitting a Concept Paper.

ARPA-E performs a preliminary review of Concept Papers to determine whether they are compliant and responsive, as described in Section III.C of the FOA. ARPA-E makes an independent assessment of each compliant and responsive Concept Paper based on the criteria and program policy factors in Sections V.A.1 and V.B.1 of the FOA.

ARPA-E will encourage a subset of Applicants to submit Full Applications. Other Applicants will be discouraged from submitting a Full Application in order to save them the time and expense of preparing an application that is unlikely to be selected for award negotiations. By discouraging the submission of a Full Application, ARPA-E intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. Unsuccessful Applicants should continue to submit innovative ideas and concepts to future FOAs.

3. FULL APPLICATIONS

Applicants must submit a Full Application by the deadline stated in the FOA. Applicants will have approximately 30 days from receipt of the Encourage/Discourage notification to prepare and submit a Full Application. Section IV.D of the FOA provides instructions on submitting a Full Application.

ARPA-E performs a preliminary review of Full Applications to determine whether they are compliant and responsive, as described in Section III.C of the FOA. ARPA-E reviews only compliant and responsive Full Applications.

4. REPLY TO REVIEWER COMMENTS

Once ARPA-E has completed its review of Full Applications, reviewer comments on compliant and responsive Full Applications are made available to Applicants via ARPA-E eXCHANGE. Applicants may submit an optional Reply to Reviewer Comments, which must be submitted by the deadline stated in the FOA. Section IV.E of the FOA provides instructions on submitting a Reply to Reviewer Comments.

ARPA-E performs a preliminary review of Replies to determine whether they are compliant, as described in Section III.C.1 of the FOA. ARPA-E will review and consider compliant Replies only. ARPA-E will review and consider each compliant and responsive Full Application, even if no Reply is submitted or if the Reply is found to be noncompliant.

5. "DOWN-SELECT" PROCESS

Once ARPA-E completes its review of Full Applications and Replies to Reviewer Comments, it may, at the Contracting Officer's discretion, perform a "down-select" of Full Applications. Through a down-select, ARPA-E may obtain additional information from select Applicants through pre-selection meetings, webinars, videoconferences, conference calls, or site visits that can be used to make a final selection determination. ARPA-E will not reimburse Applicants for travel and other expenses relating to pre-selection meetings and site visits, nor will these costs be eligible for reimbursement as pre-award costs.

ARPA-E may select applications for funding and make awards without pre-selection meetings and site visits. Participation in a pre-selection meeting or site visit with ARPA-E does not signify that Applicants have been selected for award negotiations.

6. SELECTION FOR AWARD NEGOTIATIONS

ARPA-E carefully considers all of the information obtained through the application process and makes an independent assessment of each compliant and responsive Full Application based on the criteria and program policy factors in Sections V.A.2 and V.B.1 of the FOA. ARPA-E may select or not select a Full Application for award negotiations. ARPA-E may also postpone a final selection determination on one or more Full Applications until a later date, subject to availability of funds and other factors. ARPA-E will enter into award negotiations only with selected Applicants.

Applicants are promptly notified of ARPA-E's selection determination. ARPA-E may stagger its selection determinations. As a result, some Applicants may receive their notification letter in advance of other Applicants. Please refer to Section VI.A of the FOA for guidance on award notifications.

7. MANDATORY WEBINAR

All selected Applicants, including the Principal Investigator and the financial manager for the project, are required to participate in a webinar that is held within approximately one week of the selection notification. During the webinar, ARPA-E officials present important information on the award negotiation process, including deadlines for the completion of certain actions.

B. APPLICATION FORMS

Required forms for Full Applications are available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov), including the SF-424, Budget Justification Workbook/SF-424A, Business Assurances Form, and Other Sources of Funding Disclosure Form. Sample responses to the Other Sources of Funding Disclosure Form and Business Assurances Form, and a sample Summary Slide, are also available on ARPA-E eXCHANGE. Applicants must use the templates available on ARPA-E eXCHANGE, including the template for the Concept Paper, the template for the Technical Volume of the Full Application, the ~~template for the~~ Technical Milestones ~~section of~~ Deliverables – Instructions and Examples, the template for the Summary Slide, the template~~, and~~ for the Summary for Public Release, and the template for the Reply to Reviewer Comments ~~template~~.

C. CONTENT AND FORM OF CONCEPT PAPERS

The Concept Paper is mandatory (i.e. in order to submit a Full Application, a compliant and responsive Concept Paper must have been submitted) and must conform to the following requirements:

- The Concept Paper must be submitted in Adobe PDF format.
- The Concept Paper must be written in English.
- All pages must be formatted to fit on 8-1/2 by 11 inch paper with margins not less than one inch on every side. Use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures and tables).
- The Control Number must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.

ARPA-E will not review or consider noncompliant and/or nonresponsive Concept Papers (see Section III.C of the FOA).

Each Concept Paper should be limited to a single concept or technology. Unrelated concepts and technologies should not be consolidated into a single Concept Paper.

Concept Papers must conform to the following content and form requirements, including maximum page lengths, described below. If Applicants exceed the maximum page lengths indicated below, ARPA-E will review only the authorized number of pages and disregard any additional pages.

A fillable Concept Paper template is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov.

SECTION	PAGE LIMIT	DESCRIPTION
Technology Description	2 pages maximum	• Applicants are required to describe succinctly: o The proposed technology, including its basic operating principles and how it is unique and innovative; o The proposed technology's target level of performance (Applicants should provide technical data or other support to show how the proposed target could be met); o The current state-of-the-art in the relevant field and application, including key shortcomings, limitations, and challenges; o How the proposed technology will overcome the shortcomings, limitations, and challenges in the relevant field and application; o The potential impact that the proposed project would have on the relevant field and application; o The key technical risks/issues associated with the proposed technology development plan; and o The impact that ARPA-E funding would have on the proposed project.
Addendum	2 pages maximum	• Applicants must state whether the proposed budget for their project falls into the first or second funding category below: 1. Proof-of-Concept Seedling Project: $250,000 - $999,999.99 and period of performance of 12 months or less; or 2. Technology Development Project: $1 million - $10 million or a period of performance of greater than 12 months. • Applicants may provide graphs, charts, or other data to supplement their Technology Description. • Applicants are required to describe succinctly the qualifications, experience, and capabilities of the proposed Project Team, including: o Whether the Principal Investigator (PI) and Project Team have the skill and expertise needed to successfully execute the project plan; o Whether the Applicant has prior experience which demonstrates an ability to perform R&D tasks of similar risk and complexity; o Whether the Applicant has worked together with its teaming partners on prior projects or programs; and o Whether the Applicant has adequate access to equipment and facilities necessary to accomplish the R&D effort and/or clearly

		explain how it intends to obtain access to necessary equipment and facilities.

D. CONTENT AND FORM OF FULL APPLICATIONS

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

Full Applications must conform to the following requirements:

- Each document must be submitted in the file format prescribed below.
- All Full Applications must be written in English.
- All pages must be formatted to fit on 8-1/2 by 11 inch paper with margins not less than one inch on every side. Use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures and tables).
- The Control Number must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.

ARPA-E will not review or consider noncompliant and/or nonresponsive Full Applications (see Section III.C of the FOA).

Each Full Application should be limited to a single concept or technology. Unrelated concepts and technologies should not be consolidated in a single Full Application.

Component	Required Format	Description and Information
Technical Volume	PDF	The centerpiece of the Full Application. Provides a detailed description of the proposed R&D project and Project Team. Applicants must complete the Technical Volume template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).
SF-424	PDF	Application for Federal Assistance (https://arpa-e-foa.energy.gov)
Budget Justification Workbook/SF-424A	XLS	Budget Information – Non-Construction Programs (https://arpa-e-foa.energy.gov)
Technical Milestones and Deliverables	PDF	Applicants must use the Technical Milestones and Deliverables – Instructions and Examples available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov) for the Technical Milestones and Deliverables.
Summary for Public Release	PDF	Short summary of the proposed R&D project. Intended for public release. Applicants must complete the Summary for Public Release template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).
Summary Slide	PPT	A four-panel project slide summarizing different aspects of the proposed R&D project. Applicants must complete the Summary Slide template available on ARPA-E

		eXCHANGE (https://arpa-e-foa.energy.gov). A sample Summary Slide is also available on ARPA-E eXCHANGE.
Business Assurances Form	PDF	Requires the Applicant to disclose potential improprieties, potential conflicts of interest within the Project Team, and written assurance of its cost share commitment. If the Applicant is a FFRDC, requires the Applicant to provide written authorization from the cognizant Federal agency and, if a DOE/NNSA FFRDC, a Field Work Proposal. Allows the Applicant to request a modification or waiver of the Performance of Work in the United States requirement, the Technology Transfer & Outreach (TT&O) spending requirement, and/or the U.S. manufacturing requirement. In addition, allows the Applicant to request the use of a Technology Investment Agreement. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov. A sample response to the Business Assurances Form is also available on ARPA-E eXCHANGE.
Other Sources of Funding Disclosure form	PDF	Requires the PI to describe the additionality and risks associated with the proposed project, disclose financial assistance from Federal entities, disclose funding from non-Federal entities for related work, and provide letters or other communications from private investors explaining why they decided not to fund the proposed R&D project. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov. A sample response to the Other Sources of Funding Disclosure Form is also available on ARPA-E eXCHANGE.

ARPA-E provides detailed guidance on the content and form of each component below.

1. FIRST COMPONENT: TECHNICAL VOLUME

The Technical Volume must be submitted in Adobe PDF format. A Technical Volume template is available at https://arpa-e-foa.energy.gov. The Technical Volume must conform to the following content and form requirements, including maximum page lengths. If Applicants exceed the maximum page lengths indicated below, ARPA-E will review only the authorized number of pages and disregard any additional pages.

Applicants must provide sufficient citations and references to the primary research literature to justify the claims and approaches made in the Technical Volume. ARPA-E and reviewers may review primary research literature in order to evaluate applications. However, ARPA-E and reviewers are under no obligation to review cited sources (e.g., Internet websites).

SECTION	PAGE LIMIT	DESCRIPTION
Technical Approach	1 page max.	• Provide a concise summary of the proposed R&D project. The summary should be written for a technically literate, but non-specialist, audience.
R&D Tasks	1 page max.	• Describe succinctly: o the purpose of the proposed R&D project, o the underlying hypothesis(es)/technical concept(s) guiding the approach, and o a list of the tasks the research team will undertake and accomplish to achieve this purpose.
R&D Strategy	20 pages max.	• Applicants are <u>required</u> to describe each of the following aspects of their proposal. Applicants should present supporting references, data, calculations, estimates, and/or projections to justify each set of claims, explicitly stating any variables and assumptions. o <u>Innovation and Impact</u> – Describe and justify: ▪ the performance of current state-of-the-art technology solutions in the application area addressed, ▪ how the proposed solution is a departure from currently available technology and differs from others under investigation in the field, ▪ the performance of the proposed solution, and the extent to which it represents a significant advance relative to the state of the art, ▪ the impact of the proposed solution on system-level performance metrics, including justification for any adverse effects on system performance, ▪ how the anticipated cost of the proposed solution compares with currently available technology, and the extent to which the solution can achieve a disruptive cost-performance learning curve relative to the state of the art ▪ the extent to which the technology benefits, if realized, will translate into substantial impact on one or more ARPA-E mission areas. o <u>Feasibility</u> – Describe and justify: ▪ the feasibility of the proposed technology solution, and capability of achieving the cost and performance targets at scale (i.e. large-volume/high-throughput scenario) o <u>Performance Team</u> – Describe succinctly: ▪ the members of the proposed research team, and ▪ why the proposed team is uniquely qualified to carry out the proposed research. Synopses of past research accomplishments are insufficient to demonstrate that a team is "uniquely qualified." Applicants are required to identify the unique combination of training and experience that make the proposed team uniquely qualified to successfully execute the

		proposed project. Preference will be given to multidisciplinary teams where different Project Team members complement each other and have expertise in different aspects of the technology.
Technology-to-Market Strategy	2 pages max.	• ARPA-E supports energy technology R&D projects for a limited period of time at critical high-risk points in the technology development cycle. ARPA-E technologies *are not required* to achieve commercial deployment by the end of the project period; however, funded projects must be on a reasonable path toward making substantive impact on ARPA-E's mission areas through commercial adoption and eventual wide-scale market deployment. If known, please describe: o How the proposed technology is expected to transition from the lab to deployment and adoption. Please include: description of the expected product, potential near-term and long-term markets of entry, likely commercialization approach (startup, license, etc.), specific organizations expected to be involved in the transition of the technology (partners, customers, etc.), expected timeline for commercialization; o Manufacturing and scalability risks associated with technology; o Resource needs for the next phase of development that follows the end of the ARPA-E project; and o why the proposed research is not being pursued by industry today.
Budget Summary	2 pages max.	• Applicants are required to provide a two-page budget summary, broken down by milestones. The summaries must conform to the following guidelines: o The budget summary should be clearly associated with the milestones outlined as part of the Technical R&D Plan and reflect quarterly progress on the proposed project. o All major equipment purchases must be included in the budget summary. For equipment acquired as part of the proposed R&D project, state the proposed disposition of the equipment after the project's completion. Specifically, state if the useful life of the equipment will correlate with its authorized purpose under the proposed project. o If costs are less than would normally be expected due to large amounts of previous R&D work done by one or more members of the research team, please describe and explain accordingly. o Applicants are required to estimate the potential materials and manufacturing costs of the proposed technology to justify the technology's potential to approach, meet, or exceed the cost targets given in each FOA. In making these estimations, Applicants must describe the manufacturing approaches that will most likely scale up the proposed technologies.
Qualifications, Experience, and	For each PQS, 3	• Applicants are required to provide a Personal Qualification Summary (PQS) for the PI and each Key Participant.[12] Each PQS is limited to 3 pages maximum. Curriculum vitae will not be considered. Each PQS must include:

[12] A Key Participant is any individual who would contribute in a substantive, measurable way to the execution of the proposed project.

Capabilities	pages max.	o Education/training, o Employment history, o Awards and honors, o Up to 10 peer-reviewed publications specifically related to the proposed R&D project, o Up to 10 other peer-reviewed publications demonstrating capabilities in the broad field, and o Up to 10 non-peer reviewed publications and patents demonstrating capabilities in the broad field.
Participating Organizations	1 page max.	• Describe succinctly why each proposed organization is qualified to accomplish their portion of the proposed R&D project. Please describe the Project Team's unique qualifications, expertise, equipment, or facilities that will facilitate the successful completion of the proposed project.
Prior Collaboration	1 page max.	• Describe succinctly: o any prior projects, programs, and initiatives on which the Project Team has collaborated; o the roles of each Project Team member in the project, program, or initiative; o whether the project, program, or initiative was ultimately successful; and o any management, intellectual property, or other issues that arose within the Project Team and how they were resolved.
Management Plan	1 page max.	• An effective management plan is essential to ensure continuous effective communication between performance members. Describe succinctly: o the roles of each Project Team member; o any critical handoffs/interdependencies between Project Team members; o the technical (i.e., decision-making based on technical understanding of the problem) and management (i.e., monitoring different elements of the project and technology to ensure that it is well-integrated) aspects of the Management Plan and the role of the PI.
Multi-Investigator Projects	2 pages max.	• Roles of Participants: For multi-organizational or multi-investigator projects, describe succinctly: o the roles and the work to be performed by each PI and Key Participant; o business agreements between the Applicant and each PI and Key Participant; and o how the various efforts will be integrated and managed. • Multiple PIs: Standalone Applicants and Project Teams are required to disclose if the project will include multiple PIs. If multiple PIs will be designated, identify the Contact PI/Project Coordinator, and provide a "Coordination and Management Plan" that describes the organization structure of the project as it pertains to the designation of multiple PIs. This plan should include: o process for making decisions on scientific/technical direction; o publication arrangements; o intellectual property issues; o communication plans;

		○ procedures for resolving conflicts; and ○ PIs' roles and administrative, technical, and scientific responsibilities for the project.
Intellectual Property Strategy	No page limit	• Describe specifically: ○ existing intellectual property that will be used to develop the new intellectual property; ○ new intellectual property and data that will be created as part of this effort; ○ how the intellectual property strategy will increase the probability that the proposed transformational technology will reach the market and widely penetrate the installed base; and ○ the plan for disposition/ownership of the intellectual property, including intellectual property agreements or memorandums of understanding between Project Team members.

2. SECOND COMPONENT: SF-424

The SF-424 must be submitted in Adobe PDF format. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov.

The SF-424 includes instructions for completing the form. Applicants are required to complete all required fields in accordance with the instructions.

Prime Recipients and Subrecipients are required to complete SF-LLL (Disclosure of Lobbying Activities), available at http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf, if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with your application or funding agreement. The completed SF-LLL must be appended to the SF-424.

ARPA-E provides the following supplemental guidance on completing the SF-424:

- Each Project Team should submit only one SF-424 (i.e., a Subrecipient should not submit a separate SF-424).
- Assume a project start date of 11/01/2013, or as negotiated.
- The list of certifications and assurances in Block 21 can be found at http://energy.gov/management/downloads/certifications-and-assurances-use-sf-424.

- The dates and dollar amounts on the SF-424 are for the entire project period (from the project start date to the project end date), not a portion thereof.

3. THIRD COMPONENT: BUDGET JUSTIFICATION WORKBOOK/SF-424A

Applicants are required to complete the Budget Justification Workbook/SF-424A Excel spreadsheet. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov. Prime Recipients must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the Prime Recipient and its Subrecipients and Contractors, and provide all requested documentation (e.g., a Federally-approved forward pricing rate agreement, Defense Contract Audit Agency or Government Audits and Reports, if available). The SF-424A form included with the Budget Justification Workbook will "auto-populate" as the Applicant enters information into the Workbook. Applicants must carefully read the "Instructions and Summary" tab provided within the Budget Justification Workbook.

Subrecipient information must be submitted as follows:

- Each Subrecipient incurring greater than or equal to 10% of the Total Project Cost must complete a separate Budget Justification workbook to justify its proposed budget. These worksheets must be inserted as additional sheets within in the Prime Recipient's Budget Justification.

- Subrecipients incurring less than 10% of the Total Project Cost are not required to complete a separate Budget Justification workbook. However, such Subrecipients are required to provide supporting documentation to justify their proposed budgets. At a minimum, the supporting documentation must show which tasks/subtasks are being performed, the purpose/need for the effort, and a sufficient basis for the estimated costs.

ARPA-E provides the following supplemental guidance on completing the Budget Justification Workbook/SF-424A:

- Applicants may request funds under the appropriate object class category tabs as long as the item and amount requested are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions described herein.

- If Patent costs are requested, they must be included in the Applicant's proposed budget (see Section IV.G.3 of the FOA for more information on Patent Costs).

- Unless a waiver is granted by the Contracting Officer, each Project Team must spend at least 5% of the Federal funding (i.e., the portion of the award that does not include the recipient's cost share) on Technology Transfer & Outreach (TT&O) activities to promote and further the development and deployment of ARPA-E-funded technologies. In addition, Project Teams may not expend more than 5% of the Total Project Cost on TT&O activities without the prior approval of the Contracting Officer (see Section IV.G.8 of the FOA).

- All TT&O costs requested must be included in the Applicant's proposed budget and identified as TT&O costs in the Budget Justification Workbook/SF-424A with the costs being requested under the "Other" budget category. All budgeted activities must relate to achieving specific objectives, technical milestones and deliverables outlined in the Technical Milestones and Deliverables.

- For pricing purposes, assume a project start date of 11/01/2013, or as negotiated.

- For more information, please refer to the ARPA-E Budget Justification Guidance document at https://arpa-e-foa.energy.gov.

4. FOURTH COMPONENT: TECHNICAL MILESTONES AND DELIVERABLES

Applicants must submit proposed Technical Milestones and Deliverables in one combined PDF document. The Technical Milestones and Deliverables include (1) a statement of project objectives, (2) a schedule for the work proposed in the "R&D Tasks" section of the Technical Volume, and (3) a set of detailed descriptions of the technical Tasks, Sub-Tasks, Milestones, and Deliverables. Please refer to the "Technical Milestones and Deliverables – Instructions and Examples" document available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov) for guidance on preparing the Technical Milestones and Deliverables.

The Technical Milestones and Deliverables help focus effort and resources on critical path technology components. The technical Tasks, Sub-Tasks, Milestones, and Deliverables should provide a clear path to completion of the R&D Tasks and be as quantitative and specific as possible, clearly indicating the techniques and assumptions used to determine their achievement. ARPA-E evaluates the progress of a project by comparing actual progress of completing Tasks and Sub-Tasks to predetermined technical milestones and deliverables.

End-of-Project or other milestones may be subject to independent measurement or verification. ARPA-E Program Directors may require revisions to proposed Technical Milestones and Deliverables during award negotiations. In addition, ARPA-E Program Directors may redirect, discontinue, or terminate projects that fail to achieve predetermined Technical Milestones and Deliverables.

5. FIFTH COMPONENT: SUMMARY FOR PUBLIC RELEASE

Applicants are required to provide a one-page Summary for Public Release. A Summary for Public Release template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). The Summary for Public Release must be submitted in Adobe PDF format. This summary should not include any confidential, proprietary, or privileged information. The summary should be written for a lay audience (e.g., general public, media, Congress) using plain English.

6. SIXTH COMPONENT: SUMMARY SLIDE

Applicants are required to provide a single PowerPoint slide summarizing the proposed project. The slide must be submitted in Microsoft PowerPoint format. This slide is used during the evaluation process. A summary slide template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). A sample summary slide is also available on ARPA-E eXCHANGE. Applicants must use the Summary Slide template to complete their Summary Slide.

The Summary Slide template requires the following information:

- a technology summary;
- a description of the technology's impact;
- proposed targets;
- any key graphics (illustrations, charts and/or tables);
- the project's key idea/takeaway;
- project title and Principal Investigator information; and
- requested ARPA-E funds and proposed applicant cost share.

7. SEVENTH COMPONENT: BUSINESS ASSURANCES FORM

Applicants are required to complete a Business Assurances Form. The form must be submitted in Adobe PDF format. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov. A sample response to the Business Assurances Form is also available on ARPA-E eXCHANGE.

In the Business Assurances Form, the Applicant is required to:

- Disclose potential improprieties, such as convictions for fraud and export control violations;

- Disclose potential conflicts of interest within the Project Team; and

- Provide written assurance of its cost share commitment;
- If the Applicant is a FFRDC, submit written authorization from the cognizant Federal agency; and
- If the Applicant is a DOE/NNSA FFRDC, submit a Field Work Proposal.

In addition, the Applicant may:

- Request authorization to perform some work overseas;
- Request a waiver of the TT&O spending requirement;
- Request the use of a Technology Investment Agreement instead of ARPA-E's Model Cooperative Agreement; and
- Request a modification or waiver of the U.S. Manufacturing requirement.

8. EIGHTH COMPONENT: OTHER SOURCES OF FUNDING DISCLOSURE FORM

ARPA-E is required by statute to "accelerat[e] transformational technological advances in areas that industry is by itself not likely to undertake because of technical and financial uncertainty."[13] In accordance with its statutory mandate, ARPA-E requires the PI to complete the Other Sources of Funding Disclosure Form and submit it with the Full Application. The form must be submitted in Adobe PDF format. The Other Sources of Funding Disclosure Form is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). A sample response to the Other Sources of Funding Disclosure Form is also available on ARPA-E eXCHANGE.

In the Other Sources of Funding Disclosure Form, the PI is required to:

- Describe the additionality and risks associated with the proposed R&D project;
- Disclose whether the PI or any Co-PI(s) have submitted the same application to any Federal or non-Federal entities;
- Disclose whether the PI or any Co-PI(s) have submitted any applications for related work to any Federal or non-Federal entities within the last 24 months;

[13] America COMPETES Act, Pub. L. No. 110-69, § 5012 (2007), as amended (codified at 42 U.S.C. § 16538).

- Disclose all financial assistance from any Federal entity that the PI or any Co-PI(s) is currently receiving or has received within the last 5 years;

- Disclose any funding from non-Federal entities for related work that the PI or any Co-PI(s) is currently receiving or has received within the last 5 years; and

- Provide any letters or other communications from private investors explaining why they decided not to fund the proposed R&D project or related work.

E. CONTENT AND FORM OF REPLIES TO REVIEWER COMMENTS

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

Written feedback on Full Applications is made available to Applicants before the submission deadline for Replies to Reviewer Comments. Applicants have a brief opportunity to prepare a short Reply to Reviewer Comments responding to one or more comments or supplementing their Full Application. A fillable Reply to Reviewer Comments template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). Applicants must use this Reply to Reviewer Comments template to complete their Reply to Reviewer Comments.

Replies to Reviewer Comments must conform to the following requirements:

- The Reply to Reviewer Comments must be submitted in Adobe PDF format.

- The Reply to Reviewer Comments must be written in English.

- All pages must be formatted to fit on 8-1/2 by 11 inch paper with margins not less than one inch on every side. Use Times New Roman typeface, a black font color, and a font size of 12 points or larger (except in figures and tables).

- The Control Number must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.

ARPA-E will not review or consider noncompliant Replies to Reviewer Comments (see Section III.C.1 of the FOA). ARPA-E will review and consider each compliant and responsive Full Application, even if no Reply is submitted or if the Reply is found to be noncompliant.

Replies to Reviewer Comments must conform to the following content and form requirements, including maximum page lengths, described below. If a Reply to Reviewer Comments is more than three pages in length, ARPA-E will review only the first three pages and disregard any additional pages.

SECTION	PAGE LIMIT	DESCRIPTION
Text	2 pages maximum	• Applicants may respond to one or more reviewer comments or supplement their Full Application.
Images	1 page maximum	• Applicants may provide graphs, charts, or other data to respond to reviewer comments or supplement their Full Application.

F. INTERGOVERNMENTAL REVIEW

This program is not subject to Executive Order 12372 (Intergovernmental Review of Federal Programs).

G. FUNDING RESTRICTIONS

[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]

1. ALLOWABLE COSTS

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable Federal cost principles. ARPA-E has listed the Federal cost principles for different categories of Applicants at http://arpa-e.energy.gov/FundingAgreements/Overview/PostAward.aspx#Applicable_Federal_Regulations.

2. PRE-AWARD COSTS

ARPA-E will not reimburse any pre-award costs incurred by Applicants before they are selected for award negotiations. Please refer to Section VI.A of the FOA for guidance on award notices.

Upon selection for award negotiations, Applicants may incur pre-award costs at their own risk, consistent with the requirements in 10 C.F.R. part 600 and other Federal laws and regulations. ARPA-E generally does not accept budgets as submitted with the Full Application. Budgets are typically reworked during award negotiations. ARPA-E is under no obligation to reimburse pre-award costs if, for any reason, the Applicant does not receive an award or the award is made for a lesser amount than the Applicant expected, or if the costs incurred are not allowable, allocable, or reasonable.

Given the uncertainty of award negotiations, it is strongly recommended that Prime Recipients and Subrecipients consult with the Contracting Officer (ARPA-E-CO@hq.doe.gov) before incurring any pre-award costs.

Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (http://arpa-e.energy.gov/sites/default/files/documents/files/Applicants%20Guide%20to%20ARPA-E%20Award%20Negotiations%20Nov2012.pdf) for additional guidance on pre-award costs.

3. PATENT COSTS

ARPA-E will fully reimburse the following types of patent costs:

- Cost of preparing and submitting invention disclosures to ARPA-E and DOE;
- Cost of searching the art to the extent reasonable and necessary to make invention disclosures to ARPA-E and DOE, as required by Attachment 2 to the funding agreement; and
- Cost of preparing the reports and other documents required by Attachment 2 to the funding agreement.

ARPA-E will reimburse up to $30,000 in costs and fees incurred in preparing and filing domestic and foreign patents. The Prime Recipient may request a waiver of the $30,000 cap. Because all patent costs are considered to be Technology Transfer & Outreach (TT&O) costs (see Section IV.G.8 of the FOA below), the waiver request is subject to review by the ARPA-E Program Director and approval by the Contracting Officer.

4. CONSTRUCTION

ARPA-E generally does not fund projects that involve major construction. Recipients are required to obtain written authorization from the Contracting Officer before incurring any major construction costs.

5. FOREIGN TRAVEL

ARPA-E generally does not fund projects that involve foreign travel. Recipients are required to obtain written authorization from the Contracting Officer before incurring any foreign travel costs and provide trip reports with their reimbursement requests.

6. PERFORMANCE OF WORK IN THE UNITED STATES

ARPA-E strongly encourages interdisciplinary and cross-sectoral collaboration spanning organizational boundaries. Such collaboration enables the achievement of scientific and technological outcomes that were previously viewed as extremely difficult, if not impossible.

ARPA-E requires all work under ARPA-E funding agreements to be performed in the United States – i.e., Prime Recipients must expend 100% of the Total Project Cost in the United States. However, Applicants may request a waiver of this requirement where their project would materially benefit from, or otherwise requires, certain work to be performed overseas.

Applicants seeking a waiver of this requirement are required to include an explicit request in the Business Assurances Form, which is part of the Full Application submitted to ARPA-E. Such waivers are granted where there is a demonstrated need, as determined by ARPA-E.

7. PURCHASE OF NEW EQUIPMENT

All new equipment purchased under ARPA-E funding agreements must be made or manufactured in the United States, to the maximum extent practicable. This requirement does not apply to used or leased equipment. Project Teams may purchase foreign-made equipment where comparable domestic equipment is not reasonably available.

8. TECHNOLOGY TRANSFER AND OUTREACH

By law, ARPA-E is required to contribute a percentage of appropriated funds to Technology Transfer and Outreach (TT&O) activities. In order to meet this mandate every Project Team must spend at least 5% of the Federal funding (i.e., the portion of the award that does not include the recipient's cost share) provided by ARPA-E on TT&O activities to promote and further the development and deployment of ARPA-E-funded technologies. Project Teams may not expend more than 5% of the Total Project Cost on TT&O activities without the prior approval of the Contracting Officer. Project Teams must also seek a waiver from the Contracting Officer to spend less than the minimum 5% TT&O expenditure requirement.

All TT&O expenditures are subject to the applicable Federal cost principles, as described in Section IV.G.1 of the FOA. Examples of TT&O expenditures are as follows:

- Documented travel and registration for the ARPA-E Energy Innovation Summit and other energy-related conferences and events;
- Documented travel to meet with potential suppliers, partners, or customers;
- Documented work by salaried or contract personnel to develop technology-to-market models or plans;
- Documented costs of acquiring industry-accepted market research reports; and
- Approved patent costs.

ARPA-E will not reimburse the following types of TT&O expenditures, which do not comply with Federal cost principles.

- Meals or entertainment;
- Gifts to potential suppliers, partners, or customers;
- TT&O activities that do not relate to the ARPA-E-funded technologies or to at least one objective in the Technical Milestones and Deliverables;
- Undocumented TT&O activities; and
- TT&O activities unrelated and/or unallocable to the subject award.

Applicants may seek a waiver of the TT&O requirement by including an explicit request in the Business Assurances Form. Please refer to the Business Assurances Form for guidance on the content and form of the waiver request. ARPA-E Program Directors may waive or modify the TT&O requirement, as appropriate.

For information regarding incorporation of TT&O costs into budget documentation, see Section IV.D.3 of the FOA.

Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (http://arpa-e.energy.gov/sites/default/files/documents/files/Applicants%20Guide%20to%20ARPA-E%20Award%20Negotiations%20Nov2012.pdf) for additional guidance on TT&O requirements.

9. LOBBYING

Prime Recipients and Subrecipients may not use any Federal funds to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters.[14]

Prime Recipients and Subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf) if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your application:

- An officer or employee of any Federal agency,

[14] 18 U.S.C. § 1913.

- A Member of Congress,
- An officer or employee of Congress, or
- An employee of a Member of Congress.

H. OTHER SUBMISSION REQUIREMENTS

1. USE OF ARPA-E eXCHANGE

To apply to this FOA, Applicants must register with ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/Registration.aspx). Concept Papers, Full Applications, and Replies to Reviewer Comments must be submitted through ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/login.aspx). ARPA-E will not review or consider applications submitted through other means (e.g., fax, hand delivery, email, postal mail). For detailed guidance on using ARPA-E eXCHANGE, please refer to the "ARPA-E eXCHANGE User Guide" (https://arpa-e-foa.energy.gov/Manuals.aspx).

Upon creating an application submission in ARPA-E eXCHANGE, Applicants will be assigned a Control Number. If the Applicant creates more than one application submission, a different Control Number will be assigned for each application.

Once logged in to ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/login.aspx), Applicants may access their submissions by clicking the "My Submissions" link in the navigation on the left side of the page. Every application that the Applicant has submitted to ARPA-E and the corresponding Control Number is displayed on that page. If the Applicant submits more than one application to a particular FOA, a different Control Number is shown for each application.

Applicants are responsible for meeting each submission deadline in ARPA-E eXCHANGE. **Applicants are strongly encouraged to submit their applications at least 48 hours in advance of the submission deadline.** Under normal conditions (i.e., at least 48 hours in advance of the submission deadline), Applicants should allow at least 1 hour to submit a Concept Paper, or Full Application. In addition, Applicants should allow at least 15 minutes to submit a Reply to Reviewer Comments. Once the application is submitted in ARPA-E eXCHANGE, Applicants may revise or update their application until the expiration of the applicable deadline.

Applicants should not wait until the last minute to begin the submission process. During the final hours before the submission deadline, Applicants may experience server/connection congestion that prevents them from completing the necessary steps in ARPA-E eXCHANGE to submit their applications. **ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.**

ARPA-E will not review or consider incomplete applications and applications submitted after the deadline stated in the FOA. Such applications will be deemed noncompliant (see Section III.C.1 of the FOA). The following errors could cause an application to be deemed "incomplete" and thus noncompliant:

- Failing to comply with the form and content requirements in Section IV of the FOA;
- Failing to enter required information in ARPA-E eXCHANGE;
- Failing to upload required document(s) to ARPA-E eXCHANGE;
- Uploading the wrong document(s) or application(s) to ARPA-E eXCHANGE; and
- Uploading the same document twice, but labeling it as different documents. (In the latter scenario, the Applicant failed to submit a required document.)

ARPA-E urges Applicants to carefully review their applications and to allow sufficient time for the submission of required information and documents.

V. APPLICATION REVIEW INFORMATION

A. CRITERIA

ARPA-E performs a preliminary review of Concept Papers and Full Applications to determine whether they are compliant and responsive (see Section III.C of the FOA). ARPA-E also performs a preliminary review of Replies to Reviewer Comments to determine whether they are compliant.

ARPA-E considers a mix of quantitative and qualitative criteria in determining whether to encourage the submission of a Full Application and whether to select a Full Application for award negotiations.

1. CRITERIA FOR CONCEPT PAPERS

(1) *Impact of the Proposed Technology Relative to State of the Art* (50%) - This criterion involves consideration of the following factors:

- The extent to which the proposed quantitative material and/or technology metrics demonstrate the potential for a transformational and disruptive (not incremental) advancement in one or more energy-related fields;
- The extent to which the Applicant demonstrates a profound understanding of the current state-of-the-art and presents an innovative technical approach that significantly improves performance relative to the current state-of-the-art; and
- The extent to which the Applicant demonstrates awareness of competing commercial and emerging technologies and identifies how the proposed concept/technology provides significant improvement over existing solutions.

(2) *Overall Scientific and Technical Merit* (50%) - This criterion involves consideration of the following factors:

- The extent to which the proposed approach is unique and innovative;
- The feasibility of the proposed work;
- The extent to which the Applicant proposes a sound technical approach to accomplish the proposed R&D objectives;
- The extent to which project outcomes and deliverables are clearly defined; and

- The extent to which the Applicant proposes a strong and convincing technology development strategy, including a feasible pathway to transition the program results to the next logical stage of R&D and/or directly into commercial development and deployment.

Submissions will not be evaluated against each other since they are not submitted in accordance with a common work statement. The above criteria will be weighted as follows:

Impact of the Proposed Technology Relative to State of the Art	50%
Overall Scientific and Technical Merit	50%

2. CRITERIA FOR FULL APPLICATIONS

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

Full Applications are evaluated based on the following criteria:

(1) *Impact of the Proposed Technology Relative to State of the Art* (30%) - This criterion involves consideration of the following factors:

- The extent to which the proposed quantitative material and/or technology metrics demonstrate the potential for a transformational and disruptive (not incremental) advancement in one or more energy-related fields;

- The extent to which the Applicant demonstrates a profound understanding of the current state-of-the-art and presents an innovative technical approach to significantly improve performance over the current state-of-the-art; and

- The extent to which the Applicant demonstrates awareness of competing commercial and emerging technologies and identifies how its proposed concept/technology provides significant improvement over these other solutions.

(2) *Overall Scientific and Technical Merit* (30%) - This criterion involves consideration of the following factors:

- The extent to which the proposed work is unique and innovative;

- The extent to which the proposed project is likely to meet or exceed the technical performance targets identified in this FOA;

- The feasibility of the proposed work;
- The extent to which the Applicant proposes a sound technical approach to accomplish the proposed R&D objectives;
- The extent to which the Applicant manages risk, by identifying major technical R&D risks and clearly proposes feasible, effective mitigation strategies; and
- The extent to which project outcomes and deliverables are clearly defined; and
- The extent to which the Applicant proposes a strong and convincing technology development strategy, including a feasible pathway to transition the program results to the next logical stage of R&D and/or directly into commercial development and deployment.

(3) *Qualifications, Experience, and Capabilities of the Proposed Project Team* (30%) - This criterion involves consideration of the following factors**:**

- The extent to which the PI and Project Team have the skill and expertise needed to successfully execute the project plan, evidenced by prior experience that demonstrates an ability to perform R&D of similar risk and complexity;
- The extent to which the Applicant has access to the equipment and facilities necessary to accomplish the proposed R&D effort and/or a clear plan to obtain access to necessary equipment and facilities.

(4) *Soundness of Management Plan* (10%) - This criterion involves consideration of the following factors:

- The extent to which the Applicant presents a plausible plan to manage people and resources;
- The extent to which the Applicant proposes allocation of appropriate levels of effort and resources to proposed tasks;
- Whether the proposed schedule is reasonable.

Submissions will not be evaluated against each other since they are not submitted in accordance with a common work statement. The above criteria will be weighted as follows:

Impact of the Proposed Technology Relative to State of the Art	30%
Overall Scientific and Technical Merit	30%
Qualifications, Experience, and Capabilities	30%
Sound Management Plan	10%

3. CRITERIA FOR REPLIES TO REVIEWER COMMENTS

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

ARPA-E has not established separate criteria to evaluate Replies to Reviewer Comments. Instead, Replies to Reviewer Comments are evaluated as an extension of the Full Application.

B. REVIEW AND SELECTION PROCESS

1. PROGRAM POLICY FACTORS

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

In addition to the above criteria, ARPA-E may consider the following program policy factors in determining which Full Applications to select for award negotiations:

I. **ARPA-E Portfolio Balance**. Project balances ARPA-E portfolio in one or more of the following areas:
   a. Technological diversity;
   b. Organizational diversity;
   c. Geographic diversity;
   d. Technical or commercialization risk; or
   e. Stage of technology development.

II. **Relevance to ARPA-E Mission Advancement.** Project contributes to one or more of ARPA-E's key statutory goals:
   a. Reduction of US dependence on foreign energy sources;
   b. Stimulation of domestic manufacturing;
   c. Reduction of energy-related emissions;
   d. Increase in U.S. energy efficiency;
   e. Enhancement of U.S. economic and energy security; or
   f. Promotion of U.S. advanced energy technologies competitiveness.

III. **Synergy of Public and Private Efforts**.
   a. Avoids duplication and overlap with other publicly or privately funded projects;

b. Promotes increased coordination with nongovernmental entities for demonstration of technologies and research applications to facilitate technology transfer; or
c. Increases unique research collaborations.

IV. **Low likelihood of other sources of funding.** High technical and/or financial uncertainty that results in the non-availability of other public, private or internal funding or resources to support the project.

V. **High-Leveraging of Federal Funds**. Project leverages Federal funds to optimize advancement of programmatic goals by proposing cost share above the required minimum or otherwise accessing scarce or unique resources.

VI. **High Project Impact Relative to Project Cost.**

2. ARPA-E REVIEWERS

By submitting an application to ARPA-E, Applicants consent to ARPA-E's use of Federal employees, contractors, and experts from educational institutions, nonprofits, industry, and governmental and intergovernmental entities as reviewers. ARPA-E selects reviewers based on their knowledge and understanding of the relevant field and application, their experience and skills, and their ability to provide constructive feedback on applications.

ARPA-E requires all reviewers to complete a Conflict-of-Interest Certification and Nondisclosure Agreement through which they disclose their knowledge of any actual or apparent conflicts and agree to safeguard confidential information contained in Concept Papers, Full Applications, and Replies to Reviewer Comments. In addition, ARPA-E trains its reviewers in proper evaluation techniques and procedures.

Applicants are not permitted to nominate reviewers for their applications. Applicants may contact the DOE Contracting Officer by email (ARPA-E-CO@hq.doe.gov) if they have knowledge of a potential conflict of interest or a reasonable belief that a potential conflict exists.

3. ARPA-E SUPPORT CONTRACTOR

ARPA-E utilizes contractors to assist with the evaluation of applications and project management. To avoid actual and apparent conflicts of interest, ARPA-E prohibits its support contractors from submitting or participating in the preparation of applications to ARPA-E.

By submitting an application to ARPA-E, Applicants represent that they are not performing support contractor services for ARPA-E in any capacity and did not obtain the assistance of ARPA-E's support contractor to prepare the application. ARPA-E will not consider any applications that are submitted by or prepared with the assistance of its support contractors.

C. ANTICIPATED ANNOUNCEMENT AND AWARD DATES

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

ARPA-E expects to announce selections for negotiations in approximately August 2013 and to execute funding agreements in approximately November 2013.

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. REJECTED SUBMISSIONS

Noncompliant and nonresponsive Concept Papers and Full Applications are rejected by the DOE Contracting Officer and are not reviewed or considered. The DOE Contracting Officer sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. The notification letter states the basis upon which the Concept Paper or Full Application was rejected.

2. CONCEPT PAPER NOTIFICATIONS

ARPA-E promptly notifies Applicants of its determination to encourage or discourage the submission of a Full Application. ARPA-E sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. Due to the anticipated volume of applications, ARPA-E is unable to provide feedback on Concept Papers.

Applicants may submit a Full Application even if they receive a notification discouraging them from doing so. By discouraging the submission of a Full Application, ARPA-E intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project or the Applicant. The purpose of the Concept Paper phase is to save Applicants the considerable time and expense of preparing a Full Application that is unlikely to be selected for award negotiations.

A notification letter encouraging the submission of a Full Application does not authorize the Applicant to commence performance of the project. Please refer to Section IV.G.2 of the FOA for guidance on pre-award costs.

3. FULL APPLICATION NOTIFICATIONS

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

ARPA-E promptly notifies Applicants of its determination. ARPA-E sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. The notification letter may inform the Applicant that its Full Application was selected for award negotiations, or not selected. Alternatively, ARPA-E may notify one or more Applicants that a final selection determination on particular Full Applications will be made at a later date, subject to the availability of funds or other factors.

Written feedback on Full Applications is made available to Applicants before the submission deadline for Replies to Reviewer Comments. By providing feedback, ARPA-E intends to guide the further development of the proposed technology and to provide a brief opportunity to respond to reviewer comments.

a. SUCCESSFUL APPLICANTS

ARPA-E has discretion to select all or part of a proposed project for negotiation of an award. A notification letter selecting a Full Application for award negotiations does not authorize the Applicant to commence performance of the project. **ARPA-E selects Full Applications for award negotiations, not for award.** Applicants do not receive an award until award negotiations are complete and the Contracting Officer executes the funding agreement. ARPA-E may terminate award negotiations at any time for any reason.

Please refer to Section IV.G.2 of the FOA for guidance on pre-award costs. Please also refer to the "Applicants' Guide to ARPA-E Award Negotiations" (http://arpa-e.energy.gov/sites/default/files/documents/files/Applicants%20Guide%20to%20ARPA-E%20Award%20Negotiations%20Nov2012.pdf) for guidance on the award negotiation process.

b. POSTPONED SELECTION DETERMINATIONS

A notification letter postponing a final selection determination until a later date does not authorize the Applicant to commence performance of the project. ARPA-E may ultimately determine to select or not select the Full Application for award negotiations.

Please refer to Section IV.G.2 of the FOA for guidance on pre-award costs.

c. *Unsuccessful Applicants*

By not selecting a Full Application, ARPA-E intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. ARPA-E hopes that unsuccessful Applicants will submit innovative ideas and concepts for future FOAs.

B. Administrative and National Policy Requirements

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

The following administrative and national policy requirements apply to Prime Recipients. The Prime Recipient is the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to disputes and claims arising out of any agreement between the Prime Recipient and a FFRDC contractor. Prime Recipients are required to flow down these requirements to their Subrecipients through subawards or related agreements.

1. DUNS Number and SAM, FSRS, and FedConnect Registrations

Upon selection for award negotiations, Prime Recipients and Subrecipients are required to obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number at http://fedgov.dnb.com/webform. In addition, Prime Recipients and Subrecipients are required to register with the System for Award Management (SAM) at https://www.sam.gov/portal/public/SAM/. Applicants who currently have an active record in the Central Contractor Registry (CCR) have an active record in SAM, but a new username must still be registered.

Prime Recipients and Subrecipients should commence this process as soon as possible in order to expedite the execution of a funding agreement. Obtaining a DUNS number and registering with SAM could take several weeks.

By law, Prime Recipients are also required to register with the Federal Funding Accountability and Transparency Act Subaward Reporting System (FSRS) at https://www.fsrs.gov/.[15] Prime Recipients are required to report to FSRS the names and total compensation of each of the Prime Recipient's five most highly compensated executives and the names and total compensation of each Subrecipient's five most highly compensated executives. Please refer to https://www.fsrs.gov/ for guidance on reporting requirements.

[18] The Federal Funding Accountability and Transparency Act, P.L. 109-282, 31 U.S.C. 6101 note.

ARPA-E may not execute a funding agreement with the Prime Recipient until it has obtained a DUNS number and completed its SAM and FSRS registrations. In addition, the Prime Recipient may not execute subawards with Subrecipients until they obtain a DUNS number and complete their SAM registration. Prime Recipients and Subrecipients are required to keep their SAM and FSRS data current throughout the duration of the project.

Finally, Prime Recipients are required to register with FedConnect in order to receive notification that their funding agreement has been executed by the Contracting Officer and to obtain a copy of the executed funding agreement. Please refer to https://www.fedconnect.net/FedConnect/ for registration instructions.

2. NATIONAL POLICY ASSURANCES

Project Teams, including Prime Recipients and Subrecipients, are required to comply with the National Policy Assurances attached to their funding agreement. Please refer to ARPA-E's Model Cooperative Agreement (http://arpa-e.energy.gov/FundingAgreements/CooperativeAgreements.aspx) for guidance on the National Policy Assurances.

3. PROOF OF COST SHARE COMMITMENT AND ALLOWABILITY

Upon selection for award negotiations, the Prime Recipient must confirm in writing that the proposed cost share contribution is allowable in accordance with applicable Federal cost principles.

The Prime Recipient is also required to provide cost share commitment letters from Subrecipients or third parties that are providing cost share, whether cash or in-kind. Each Subrecipient or third party that is contributing cost share must provide a letter on appropriate letterhead that is signed by an authorized corporate representative. Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (http://arpa-e.energy.gov/sites/default/files/documents/files/Applicants%20Guide%20to%20ARPA-E%20Award%20Negotiations%20Nov2012.pdf) for guidance on the contents of cost share commitment letters.

4. COST SHARE PAYMENTS[16]

All proposed cost share contributions must be reviewed in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

[19] Please refer to Section III.B of the FOA for guidance on cost share requirements.

ARPA-E requires Prime Recipients to contribute the cost share amount incrementally over the life of the funding agreement.[17] Specifically, every Prime Recipient is required to contribute, at a minimum, the cost share percentage of total expenditures incurred during every billing period. For example, a Prime Recipient is required to contribute at least 31% of the total expenditures incurred during every billing period if the funding agreement states that the cost share percentage is 31%.

Prime Recipients must submit written documentation with every reimbursement request demonstrating that it (or Project Team, as appropriate) has provided the requisite cost share during the relevant billing period.

If Prime Recipients anticipate difficulty providing the requisite cost share every billing period, they may request authorization from the Contracting Officer upon selection for award negotiations to deviate from ARPA-E's standard cost share payment schedule.

Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (http://arpa-e.energy.gov/sites/default/files/documents/files/Applicants%20Guide%20to%20ARPA-E%20Award%20Negotiations%20Nov2012.pdf) for additional guidance on cost share payment requirements.

ARPA-E may deny reimbursement requests, in whole or in part, or modify or terminate funding agreements where Prime Recipients (or Project Teams) fail to comply with ARPA-E's cost share payment requirements.

5. ENVIRONMENTAL IMPACT QUESTIONNAIRE

By law, ARPA-E is required to evaluate the potential environmental impact of projects that it is considering for funding. In particular, ARPA-E must determine before funding a project whether the project qualifies for a categorical exclusion under 10 C.F.R. § 1021.410 or whether it requires further environmental review (i.e., an environmental assessment or an environmental impact statement).

To facilitate and expedite ARPA-E's environmental review, Prime Recipients are required to complete an Environmental Impact Questionnaire during award negotiations. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov. The Environmental Impact Questionnaire is due within 21 calendar days of the selection announcement.

[20] Prime Recipients may elect to pay the entire cost share amount at the start of the project.

6. TECHNOLOGY-TO-MARKET PLAN

During award negotiations, Prime Recipients are required to negotiate and submit an initial Technology-to-Market Plan to the ARPA-E Program Director, and obtain the ARPA-E Program Director's approval prior to the execution of the award. Prime Recipients must show how budgeted Technology Transfer and Outreach (TT&O) costs relate to furthering elements of the Technology-to-Market Plan. During the project period, Prime Recipients are required to provide regular updates on the initial Technology-to-Market plan and report on implementation of Technology-to-Market activities. Prime Recipients may be required to perform other actions to further the commercialization of their respective technologies.

ARPA-E Program Directors may waive or modify this requirement, as appropriate.

7. INTELLECTUAL PROPERTY MANAGEMENT PLAN

ARPA-E requires every Project Team to negotiate and establish an Intellectual Property Management Plan for the management and disposition of intellectual property arising from the project. The Prime Recipient must submit a completed and signed Intellectual Property Management plan to ARPA-E within six weeks of the effective date of the ARPA-E funding agreement. All Intellectual Property Management Plans are subject to the terms and conditions of the ARPA-E funding agreement and its intellectual property provisions, and applicable Federal laws, regulations, and policies, all of which take precedence over the terms of Intellectual Property Management Plans.

ARPA-E has developed a template for Intellectual Property Management Plans (http://arpa-e.energy.gov/FundingAgreements/Overview.aspx) so as to facilitate and expedite negotiations between Project Team members. ARPA-E does not mandate the use of this template. ARPA-E and DOE do not make any warranty (express or implied) or assume any liability or responsibility for the accuracy, completeness, or usefulness of the template. ARPA-E and DOE strongly encourage Project Teams to consult independent legal counsel before using the template.

8. U.S. MANUFACTURING REQUIREMENT

ARPA-E requires products embodying or produced through the use of subject inventions (i.e., inventions conceived or first actually reduced to practice under ARPA-E funding agreements) to be substantially manufactured in the United States by Project Teams and their licensees, as described below. The Applicant may request a modification or waiver of the U.S. Manufacturing Requirement through the Business Assurances Form submitted with the Full Application.

a. SMALL BUSINESSES

Small businesses (including Small Business Concerns) that are Prime Recipients or Subrecipients under ARPA-E funding agreements are required to substantially manufacture the following products in the United States for any use or sale in the United States: (1) products embodying subject inventions, and (2) products produced through the use of subject invention(s).[18] This requirement does not apply to products that are manufactured for use or sale outside the U.S. A.

Small businesses must apply the same U.S. Manufacturing requirements to their assignees, licensees, and entities acquiring a controlling interest in the small business. Small businesses must require their assignees and entities acquiring a controlling interest in the small business to apply the same U.S. Manufacturing requirements to their licensees.

b. LARGE BUSINESSES AND FOREIGN ENTITIES

Large businesses and foreign entities that are Prime Recipients or Subrecipients under ARPA-E funding agreements are required to substantially manufacture the following products in the United States: (1) products embodying subject inventions, and (2) products produced through the use of subject invention(s).[19] This requirement applies to products that are manufactured for use or sale in the United States and outside the United States.

Large businesses and foreign entities must apply the same U.S. Manufacturing requirements to their assignees, licensees, and entities acquiring a controlling interest in the large business or foreign entity. Large businesses and foreign entities must require their assignees and entities acquiring a controlling interest in the large business or foreign entity to apply the same U.S. Manufacturing requirements to their licensees.

c. EDUCATIONAL INSTITUTIONS AND NONPROFITS

Domestic educational institutions and nonprofits that are Prime Recipients or Subrecipients under ARPA-E funding agreements must require their exclusive licensees to substantially manufacture the following products in the United States for any use or sale in the United

[22] Small businesses are generally defined as domestically incorporated entities that meet the criteria established by the U.S. Small Business Administration's "Table of Small Business Size Standards Matched to North American Industry Classification System Codes" (http://www.sba.gov/sites/default/files/Size_Standards_Table.pdf).

[19] Large businesses are generally defined as domestically incorporated entities that do not meet the criteria established by the U.S. Small Business Administration's "Table of Small Business Size Standards Matched to North American Industry Classification System Codes" (http://www.sba.gov/sites/default/files/Size_Standards_Table.pdf).

States: (1) articles embodying subject inventions, and (2) articles produced through the use of subject invention(s). This requirement does not apply to articles that are manufactured for use or sale overseas.

Educational institutions and nonprofits must require their assignees to apply the same U.S. Manufacturing requirements to their exclusive licensees.

These U.S. Manufacturing requirements do not apply to nonexclusive licensees.

d. FFRDCs and State and Local Government Entities

FFRDCs and state and local government entities are subject to the same U.S. Manufacturing requirements as domestic educational institutions and nonprofits.

C. REPORTING

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

Recipients are required to submit periodic, detailed reports on technical, financial, and other aspects of the project, as described in Attachment 4 to ARPA-E's Model Cooperative Agreement (http://arpa-e.energy.gov/FundingAgreements/CooperativeAgreements.aspx).

VII. AGENCY CONTACTS

A. COMMUNICATIONS WITH ARPA-E

Upon the issuance of a FOA, ARPA-E personnel are prohibited from communicating (in writing or otherwise) with Applicants regarding the FOA. This "quiet period" remains in effect until ARPA-E's public announcement of its project selections.

During the "quiet period," Applicants are required to submit all questions regarding this FOA to ARPA-E-CO@hq.doe.gov.

- ARPA-E will post responses on a weekly basis to any questions that are received. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.

- ARPA-E will cease to accept questions approximately 5 business days in advance of each submission deadline. Responses to questions received before the cutoff will be posted approximately one business day in advance of the submission deadline. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.

- Responses are posted to "Frequently Asked Questions" on ARPA-E's website (http://arpa-e.energy.gov/faq).

Applicants may submit questions regarding ARPA-E eXCHANGE, ARPA-E's online application portal, to ExchangeHelp@hq.doe.gov. ARPA-E will promptly respond to emails that raise legitimate, technical issues with ARPA-E eXCHANGE. ARPA-E will refer any questions regarding the FOA to ARPA-E-CO@hq.doe.gov.

ARPA-E will not accept or respond to communications received by other means (e.g., fax, telephone, mail, hand delivery). Emails sent to other email addresses will be disregarded.

During the "quiet period," only the DOE Contracting Officer may authorize communications between ARPA-E personnel and Applicants. The DOE Contracting Officer may communicate with Applicants as necessary and appropriate. As described in Section ~~I.B~~ IV.A of the FOA, the DOE Contracting Officer may arrange pre-selection meetings and/or site visits during the "quiet period."

B. DEBRIEFINGS

ARPA-E does not offer or provide debriefings. ARPA-E provides Applicants with a notification encouraging or discouraging the submission of a Full Application based on ARPA-E's assessment of the Concept Paper. In addition, ARPA-E provides Applicants with reviewer comments on Full Applications before the submission deadline for Replies to Reviewer Comments.

VIII. OTHER INFORMATION

A. FOAS AND FOA MODIFICATIONS

FOAs are posted on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/), Grants.gov (http://www.grants.gov/), and FedConnect (https://www.fedconnect.net/FedConnect/). Any modifications to the FOA are also posted to these websites. You can receive an e-mail when a modification is posted by registering with FedConnect as an interested party for this FOA. It is recommended that you register as soon as possible after release of the FOA to ensure that you receive timely notice of any modifications or other announcements. More information is available at https://www.fedconnect.net.

B. OBLIGATION OF PUBLIC FUNDS

The DOE Contracting Officer is the only individual who can make awards on behalf of ARPA-E or obligate ARPA-E to the expenditure of public funds. A commitment or obligation by any individual other than the DOE Contracting Officer, either explicit or implied, is invalid.

ARPA-E awards may not be transferred, assigned, or assumed without the prior written consent of a Contracting Officer.

C. REQUIREMENT FOR FULL AND COMPLETE DISCLOSURE

Applicants are required to make a full and complete disclosure of the information requested in the Business Assurances Form and the Other Sources of Funding Disclosure form. Disclosure of the requested information is mandatory. Any failure to make a full and complete disclosure of the requested information may result in:

- The rejection of a Concept Paper, Full Application, and/or Reply to Reviewer Comments;
- The termination of award negotiations;

- The modification, suspension, and/or termination of a funding agreement;

- The initiation of debarment proceedings, debarment, and/or a declaration of ineligibility for receipt of Federal contracts, subcontracts, and financial assistance and benefits; and

- Civil and/or criminal penalties.

D. RETENTION OF SUBMISSIONS

ARPA-E expects to retain copies of all Concept Papers, Full Applications, Replies to Reviewer Comments, and other submissions. No submissions will be returned. By applying to ARPA-E for funding, Applicants consent to ARPA-E's retention of their submissions.

E. MARKING OF CONFIDENTIAL INFORMATION

ARPA-E will use data and other information contained in Concept Papers, Full Applications, and Replies to Reviewer Comments strictly for evaluation purposes. Applicants should not include confidential, proprietary, or privileged information in their Concept Papers, Full Applications, or Replies to Reviewer Comments unless such information is necessary to convey an understanding of the proposed project.

Concept Papers, Full Applications, Replies to Reviewer Comments, and other submissions containing confidential, proprietary, or privileged information must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

The cover sheet of the Concept Paper, Full Application, Reply to Reviewer Comments, or other submission must be marked as follows and identify the specific pages containing confidential, proprietary, or privileged information:

> Notice of Restriction on Disclosure and Use of Data:
>
> Pages [___] of this document may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance or loan agreement between the submitter and the Government. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

The header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure." In addition, every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

F. TITLE TO SUBJECT INVENTIONS

Ownership of subject inventions is governed pursuant to the authorities listed below. Typically, either by operation of law or under the authority of a patent waiver, Prime Recipients and Subrecipients may elect to retain title to their subject inventions under ARPA-E funding agreements.

- Domestic Small Businesses, Educational Institutions, and Nonprofits: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), domestic small businesses, educational institutions, and nonprofits may elect to retain title to their subject inventions. If they elect to retain title, they must file a patent application in a timely fashion.

- All other parties: The Federal Non Nuclear Energy Act of 1974, 42. U.S.C. 5908, provides that the Government obtains title to new inventions unless a waiver is granted (*see below)*.

- Class Waiver: Under 42 U.S.C. § 5908, title to subject inventions vests in the U.S. Government and large businesses and foreign entities do not have the automatic right to elect to retain title to subject inventions. However, ARPA-E typically issues "class patent waivers" under which large businesses and foreign entities that meet certain stated requirements may elect to retain title to their subject inventions. If a large business or foreign entity elects to retain title to its subject invention, it must file a patent application in a timely fashion.

G. GOVERNMENT RIGHTS IN SUBJECT INVENTIONS

Where Prime Recipients and Subrecipients retain title to subject inventions, the U.S. Government retains certain rights.

1. GOVERNMENT USE LICENSE

The U.S. Government retains a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any subject invention

throughout the world. This license extends to contractors doing work on behalf of the Government.

2. MARCH-IN RIGHTS

The U.S. Government retains march-in rights with respect to all subject inventions. Through "march-in rights," the Government may require a Prime Recipient or Subrecipient who has elected to retain title to a subject invention (or their assignees or exclusive licensees), to grant a license for use of the invention. In addition, the Government may grant licenses for use of the subject invention when Prime Recipients, Subrecipients, or their assignees and exclusive licensees refuse to do so.

The U.S. Government may exercise its march-in rights if it determines that such action is necessary under any of the four following conditions:

- The owner or licensee has not taken or is not expected to take effective steps to achieve practical application of the invention within a reasonable time;
- The owner or licensee has not taken action to alleviate health or safety needs in a reasonably ~~satisfied~~ satisfactory manner;
- The owner has not met public use requirements specified by Federal statutes in a reasonably ~~satisfied~~ satisfactory manner; or
- The U.S. Manufacturing requirement has not been met.

H. RIGHTS IN TECHNICAL DATA

Data rights differ based on whether data is first produced under an award or instead was developed at private expense outside the award.

- Background or "Limited Rights Data": The U.S. Government will not normally require delivery of technical data developed solely at private expense prior to issuance of an award, except as necessary to monitor technical progress and evaluate the potential of proposed technologies to reach specific technical and cost metrics.
- Generated Data: The U.S. Government normally retains very broad rights in technical data produced under Government financial assistance awards, including the right to distribute to the public. However, pursuant to special statutory authority, certain categories of data generated under ARPA-E awards may be protected from public disclosure for up to five years. Such data should be clearly marked as described in Section VIII.E of the FOA. In addition, invention disclosures

may be protected from public disclosure for a reasonable time in order to allow for filing a patent application.

I. PROTECTED PERSONALLY IDENTIFIABLE INFORMATION

Applicants may not include any Protected Personally Identifiable Information (Protected PII) in their submissions to ARPA-E. Protected PII is defined as data that, if compromised, could cause harm to an individual such as identity theft. Listed below are examples of Protected PII that Applicants must not include in their submissions.

- Social Security Numbers in any form;
- Place of Birth associated with an individual;
- Date of Birth associated with an individual;
- Mother's maiden name associated with an individual;
- Biometric record associated with an individual;
- Fingerprint;
- Iris scan;
- DNA;
- Medical history information associated with an individual;
- Medical conditions, including history of disease;
- Metric information, e.g. weight, height, blood pressure;
- Criminal history associated with an individual;
- Ratings;
- Disciplinary actions;
- Performance elements and standards (or work expectations) are PII when they are so intertwined with performance appraisals that their disclosure would reveal an individual's performance appraisal;
- Financial information associated with an individual;
- Credit card numbers;
- Bank account numbers; and
- Security clearance history or related information (not including actual clearances held).

J. ANNUAL COMPLIANCE AUDITS FOR FOR-PROFIT ENTITIES

~~[TO BE INSERTED BY FOA MODIFICATION IN MAY 2013]~~

If a for-profit entity is a Prime Recipient or Subrecipient, an annual compliance audit performed by an independent auditor may be required. For additional information, please refer to 10 C.F.R. § 600.316 and for-profit audit guidance documents posted under the "Coverage of

Independent Audits" heading at http://management.energy.gov/business_doe/business_forms.htm.

IX. GLOSSARY

Applicant: The entity that submits the application to ARPA-E. In the case of a Project Team, the Applicant is the lead organization listed on the application.

Application: The entire submission received by ARPA-E, including the Concept Paper, Full Application, and Reply to Reviewer Comments.

ARPA-E: Advanced Research Projects Agency-Energy.

Cost Share: The Prime Recipient share of the Total Project Cost.

Deliverable: A deliverable is the quantifiable goods or services that will be provided upon the successful completion of a project task or sub-task.

DOE: U.S. Department of Energy.

DOE/NNSA: U.S. Department of Energy/National Nuclear Security Administration

Down-Select Process: Once ARPA-E completes its review of Full Applications and Replies to Reviewer Comments, it will perform a "down-select" of Full Applications. Certain Applicants will be invited to participate in a meeting with ARPA-E via webinar, videoconference, or conference call. In the alternative, ARPA-E may invite Applicants to meet in person at ARPA-E's offices, the recipient's site, or a mutually agreed upon location. ARPA-E may also conduct pre-selection site visits to certain Applicants' facilities.

FFRDCs: Federally Funded Research and Development Centers.

FOA: Funding Opportunity Announcement.

GOGOs: U.S. Government-Owned, Government-Operated laboratories.

Key Participant: Any individual who would contribute in a substantive, measurable way to the execution of the proposed project.

Milestone: A milestone is the tangible, observable measurement that will be provided upon the successful completion of a project task or sub-task.

Prime Recipient: The signatory to the funding agreement with ARPA-E.

PI: Principal Investigator.

Processing Energy: The total amount of energy required to extract primary metal from ore.

Project Team: A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.

R&D: Research and development.

Standalone Applicant: An Applicant that applies for funding on its own, not as part of a Project Team.

Subject Invention: Any invention conceived or first actually reduced to practice under an ARPA-E funding agreement.

Task: A task is an operation or segment of the work plan that requires both effort and resources. Each task (or sub-task) is connected to the overall objective of the project, via the achievement of a milestone or a deliverable.

Total Project Cost: The sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by FFRDCs and GOGOs.

TT&O: Technology Transfer and Outreach. (See Section IV.G.8 of the FOA for more information).