FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

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

MICRO-SCALE OPTIMIZED SOLAR-CELL ARRAYS WITH INTEGRATED CONCENTRATION (MOSAIC)

Announcement Type: Initial Announcement
Funding Opportunity No. DE-FOA-0001255
CFDA Number 81.135

FOA Issue Date:	December 8, 2014
First Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, January 15, 2014
Submission Deadline for Concept Papers:	5 PM ET, January 22, 2015
Second Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, TBD
Submission Deadline for Full Applications:	5 PM ET, TBD
Submission Deadline for Replies to Reviewer Comments:	5 PM ET, TBD
Expected Date for Selection Notifications:	TBD
Total Amount to Be Awarded	Approximately $15 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).

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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 not exceed 4 pages in length and must include the following: o Concept Summary o Innovation and Impact o Proposed Work o Team Organization and Capabilities • The Concept Paper must be accompanied by: o Summary Slide (1 page limit, Microsoft PowerPoint format) –A Summary Slide template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).	Mandatory	IV.C	5 PM ET, January 22, 2015
Full Application	[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]	Mandatory	IV.D	5 PM ET, TBD
Reply to Reviewer Comments	[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]	Optional	IV.E	5 PM ET, TBD

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.

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.
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 real-world 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.

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

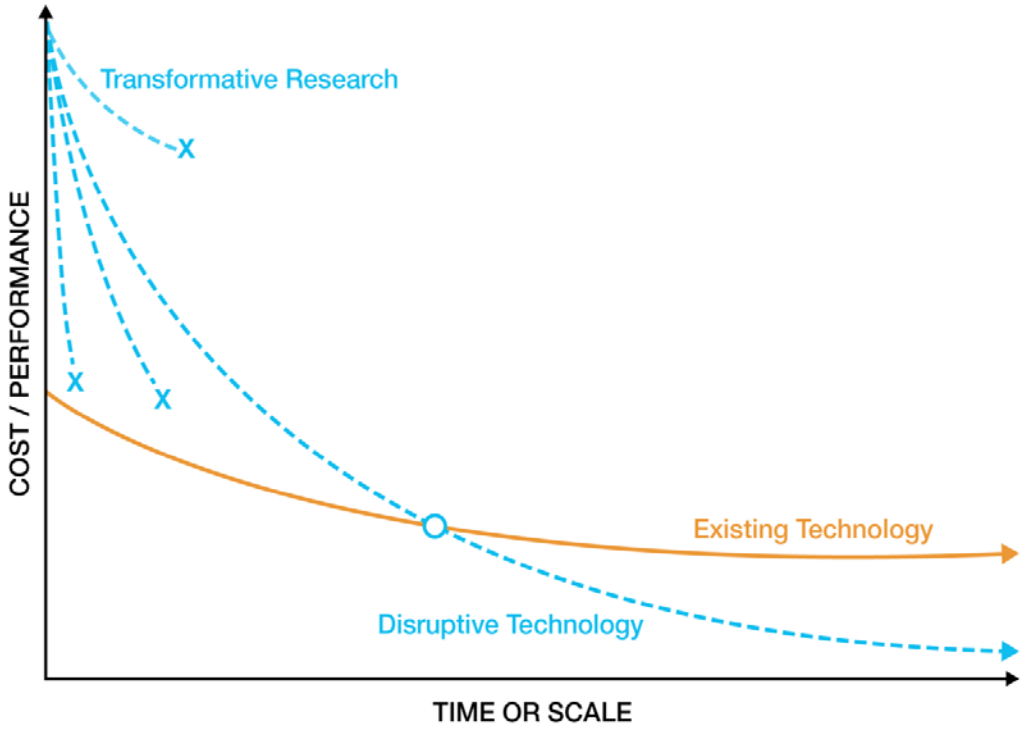

Figure 1. Description of transformational and disruptive technologies in terms of cost per unit performance versus time or scale. ARPA-E seeks to support research that establishes new learning curves that lead to disruptive technologies.

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 the economies of scale that accrue as manufacturing and widespread distribution develop drive technology down that learning curve until an equilibrium cost/performance is reached. 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 drives 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

1. SUMMARY

The ***MOSAIC*** *(**M**icro-scale **O**ptimized **S**olar-cell **A**rrays with **I**ntegrated **C**oncentration)* Program will fund potentially disruptive technologies and related system concepts to achieve new performance and cost benchmarks for solar-electric generation from photovoltaics (PV). Specifically, ***MOSAIC*** will develop novel concepts that integrate arrays of high-performance micro-scale concentrated PV (micro-CPV) elements into modules that are similar in profile and cost to traditional non-concentrated "flat-plate" (FP) PV, but achieve the performance level

associated with conventional Concentrated Photovoltaics (CPV). Realization of the aggressive targets of ***MOSAIC*** will require the formation of R&D teams from several communities, including material scientists, electrical and packaging engineers, optical engineers, micro-scale manufacturing specialists, and researchers in polymers and opto-electronics.

The ***MOSAIC*** Program's overall technical target is solar-to-electrical power conversion efficiency (as measured against total annual incident solar radiation) of > 30% across a wide range of geographic locations with varying amounts of direct and diffuse insolation. This would represent an approximately 50% improvement over conventional "1-sun" FP PV module performance. Such an advance will significantly reduce the area and number of modules needed to provide a given power output – and thereby reduce those Balance of System (BOS) costs associated with installation and maintenance that are proportional to installed system area. If micro-CPV-based panels achieve production costs comparable to those of 1-sun conventional panels (now roughly $\$100/m^2$), then the benefit from reduced BOS costs will lead to system costs as low as \$0.75/W and \$1.25/W for utility and residential market applications, respectively, resulting in a decrease in the PV-generated Levelized Cost of Energy (LCOE) across a wide geographic domain. Further, the significant reduction in the footprint needed for a given power output may also expand the adoption of PV solar in the constrained-space rooftop market, where many roofs are currently too small, too shaded, or sub-optimally oriented for installation of today's PV panel technology to be economical.

2. BACKGROUND

Solar PV technology offers a renewable-energy source of electricity at a cost that is increasingly competitive with fossil-fuel power generation. Advances in system performance (measured in $Watts/m^2$) and economies-of-scale in manufacturing (represented in $\$/m^2$) have substantially reduced cost from ~\$8-10/W at the system level in 2003 to \$2-4/W in 2013[1]. This translates to unsubsidized LCOE values as low as \$0.08/kWh. Of the 38 GW of PV product deployed in 2013, which enabled a ~\$100B PV systems market, more than 99%[2] was in the form of 1-Sun FP modules and systems. FP Crystalline Silicon (c-Si) module technologies typically achieve 16-20% conversion efficiency for the lowest cost of production.

CPV continues to make advances in system performance, reliability, and form-factor, but has not achieved widespread adoption. Further, the technology is currently considered viable only in a limited geographic region (i.e., the southwestern portions of the US) where the proportion of direct solar radiation (in contrast to diffuse solar radiation resulting from atmospheric light scattering) is maximized.

Current DOE programs in the Office of Energy Efficiency and Renewable Energy (EERE) (e.g., "SunShot") are developing FP and CPV technologies with cost targets of \$1.00/W and \$1.50/W

[1] http://www.nrel.gov/docs/fy13osti/60207.pdf
[2] http://www.semiconductor-today.com/news_items/2013/DEC/IHS_111213.shtml

for utility and residential markets, respectively. These programs and others have helped advance these technologies in both performance and cost. Consequently, there is increasing deployment of solar PV across the utility, commercial, and residential rooftop markets – and projections are for continued strong growth in solar PV adoption.

Estimates by the DOE's National Renewable Energy Laboratory (NREL) suggest that deploying PV systems on all available US residential roof space could provide as much as 500 GW of power generating capacity with 20% efficient panels —which amounts to a significant portion of the total US Electrical Power demand[3]. In principle, the combination of commercial and residential roof space and centralized utility solar farms, in conjunction with projected improvements in energy storage cost and performance, could provide all US electricity demand in a carbon-free form.

3. MOTIVATION

a. Cost Analysis

Achieving wide-spread deployment will require PV to be cost-competitive across the widest possible set of markets. Estimates using the NREL Open PV Project[4] suggest that if PV systems can achieve a $1/W cost for a 5 kW residential rooftop system, the cost of electricity in the majority of US states would be equal to or less than the cost of electricity from other sources, such as natural gas power plants. The primary challenge to reaching these target cost benchmarks is to reduce BOS costs that are independent of FP module performance enhancements. Though FP module efficiency will continue to improve, achieving incremental improvements in a cost-effective manner will become increasingly difficult as c-Si approaches to within a few absolute percent of its Shockley-Queisser efficiency limit (~29%.).

A significant portion of the BOS costs is proportional to total panel area (e.g., those associated with panel site preparation, installation, and maintenance). Consequently, increasing panel efficiency beyond what single-junction Si PV cells can achieve would have a direct impact on system BOS costs. Figure 2 shows the potential impact of increased panel efficiency on overall cost/W for an exemplar roof-top system. Since higher efficiency modules yield more output for a fixed area, the BOS costs are reduced on a per Watt basis as the efficiency is increased.

The ***MOSAIC*** Program's overall technical approach is therefore based on achieving system cost targets using integrated concentration to significantly increase PV module efficiency, but without increasing manufacturing costs appreciably. If FP PV panel costs can be nearly equaled while realizing the performance enhancement of CPV, then the geographic domain within which CPV is economical can be expanded.

[3] http://www.nrel.gov/docs/fy09osti/44073.pdf
[4] https://openpv.nrel.gov/

Flat-panel display (FPD) technology provides an "existence proof" that complex micro-scale opto-electronic circuit technology can significantly impact the marketplace. The widespread deployment of FPDs has led to significant cost reductions in materials and non-material costs with each succeeding technology generation. ***MOSAIC*** technology could follow a similar path if deployment levels lead to significant exploitation of the economies-of-scale.

In addition, increasing PV module efficiency will expand the constrained-space PV market opportunity (e.g., small residential roof-tops with more limited access to solar illumination) – where current c-Si FP PV efficiency is not sufficient to justify PV installations and high-efficiency 1-sun PV based on multi-band gap III-V materials remains too expensive. Currently, CPV concepts exploit the high performance of III-V multi-band gap PV cells, and minimize the cost by using concentration that reduces the amount of expensive PV material required. Conventional CPV systems, however, are limited in their application domains due to their bulky form factor, reliance on only the direct component of the solar insolation, and need for expensive mechanical tracking mechanisms.

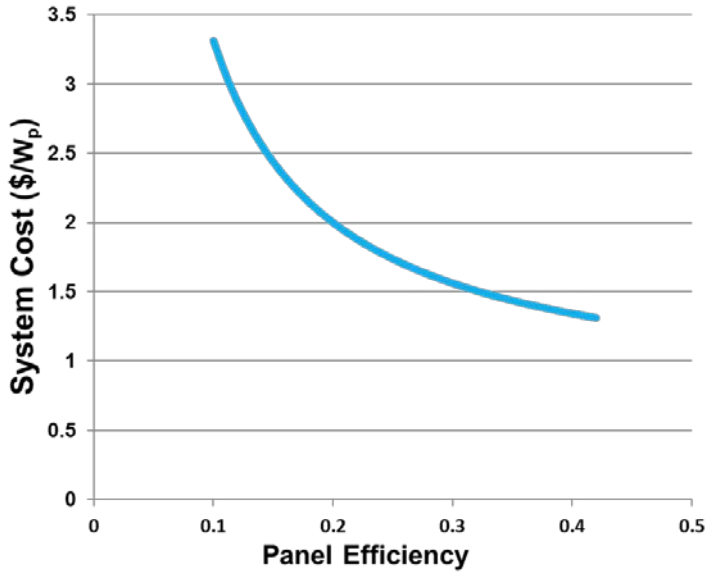

Figure 2. Estimated impact of module efficiency on system cost for a 400 ft^2 roof-top system. The analysis assumes a panel cost: \$.50/W$_p$ and a baseline BOS cost (at 20% panel efficiency) of \$1.50/W$_p$.

b. Comparison to Conventional Flat-Plate PV and Concentrating PV

In a typical FP PV module, nearly all of the module area is covered with active semiconductor material that absorbs sunlight and converts it to electrical energy. The PV "converter" material, the associated electronic materials, and the cost of manufacturing these elements account for about half of the module cost. Packaging materials, such as glass and polymers that provide environmental protection, make up the balance. Within this material set, therefore, there is a need to balance the quality and cost of the materials and manufacturing processes used with the performance they provide. Crystalline Si (c-Si) and various thin-film materials fabricated

into single-junction solar cells offer that balance. When packaged into a completed module, their streamlined form-factor and weight subsequently determine the kind and cost of mechanical structures that can be employed to install them in the field. These structures, plus additional electrical components, installation, engineering design, site preparation and permitting constitute the BOS. While FP 1-Sun solar cell modules can be fabricated from III-V materials with the efficiency sought by this program, it is unlikely that such approaches can achieve cost parity with c-Si or other single junction thin-film technologies.

In CPV, the approach is significantly different. Complex multi-junction solar cells employing expensive starting materials, and manufactured by higher-cost batch processing, are designed and fabricated to produce the highest possible efficiency. Whereas the areal cost of Si and thin-film solar materials that produce 15-20% efficiency modules are in the range of \$60-\$120/m^2, the areal cost of multi-junction cells with efficiencies of ~40% may reach \$60,000/m^2 [5]. The exploitation of such high-efficiency PV material requires that the area percentage of coverage of the solar cell material be as small as possible, with optical elements employed to collect and concentrate the light onto the smaller cell area. The intensity of the concentrated sunlight ranges from about 20 to ~1500 times the 1-Sun intensity. In recent years, there has been considerable progress in reducing the manufacturing cost of CPV by "lifting off" high-efficiency III-V cells and re-use of expensive wafer substrates, thus potentially enabling lower concentration systems and simplified module architectures.

Figure 3 shows the trade space between harvesting density and cost density in PV systems. For reference, the 10 cents/kWh boundary, which is roughly where PV becomes competitive with other forms of electrical energy generation, is depicted. With the selected axes, points above the diagonal line correspond to systems with system costs of <10 cents/kWh. Any given system's placement on the chart will depend on its geographic location (and hence total solar insolation levels) and cost (which will differ depending on market sector). In general, there is a trade-off between energy harvesting density and cost density, with projected conventional CPV and 1-sun PV systems falling in the regions shown. In keeping with the goal of ***MOSAIC*** to achieve the form-factor of 1-sun panels while approaching the harvesting performance of CPV, opportunities for ***MOSAIC*** technology are expected to lie in the region between CPV and 1-sun projections, as depicted.

[5] T. James *et al*, "Installed system cost targets for high concentration photovoltaic (HCPV) power systems," presented at UCSB Technology Roundtable: Focus on Concentrator Photovoltaics, July 25, 2012.

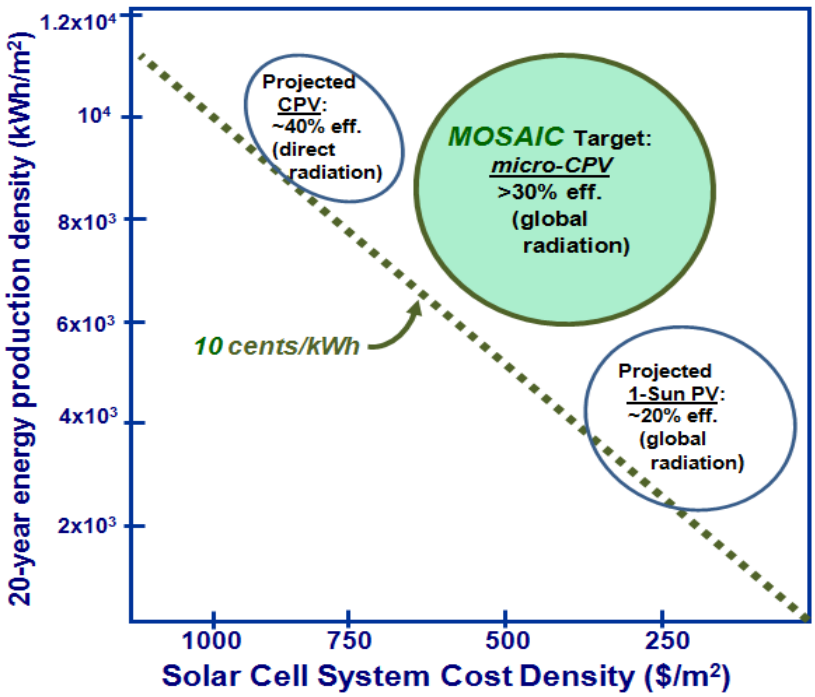

Figure 3. PV system energy harvesting potential vs. cost density: Projections show where future conventional CPV and 1-Sun PV systems will likely fall in order to achieve a <10 cents/kWh target. The ***MOSAIC*** opportunity falls in the space between these two domains, where the goal is to implement micro-CPV in a manner that achieves CPV harvesting performance, but with panel costs similar to 1-Sun FP costs.

c. Market Expansion Opportunity

Global PV markets have grown dramatically in the past decade – from 566 MW in 2003 to over 38,000 MW in 2013.[6] During the same time period, market demographics have shifted away from Europe where its market share peaked in 2008 at 85% and has since dropped to 29%, where it is second behind China[7]. The U.S. market has also demonstrated strong growth, representing ~13% of the world market in 2013 with a compound annual growth rate from 2008 to 2013 of greater than 58%[8]. While this growth is impressive, solar PV still represents only 1.1% of U.S. power generation capacity and 0.2% of total energy generation.[9] In order to substantially increase PV penetration, further technological innovation and cost reductions are necessary. ***MOSAIC*** aims to benefit all three primary market sectors – residential, commercial and utility - with higher performance, lower cost technology.

[6] http://www.epia.org/fileadmin/user_upload/Publications/EPIA_Global_Market_Outlook_for_Photovoltaics_2014-2018_-_Medium_Res.pdf
[7] Ibid (same as prior source above)
[8] http://www.nrel.gov/docs/fy14osti/60197.pdf
[9] http://www.eia.gov/electricity/monthly/pdf/epm.pdf

A typical target for alternative energy technologies is to achieve "grid parity," providing lower cost electricity than the utility grid. The variability of utility rates, in conjunction with the geographic variability for solar resources, manifests in a broad range of target values for solar PV cost. DOE's SunShot initiative has set a goal of $1.00/W for utility-scale PV. Significant progress has been made in 1-Sun FP PV – reaching levels below $2.00/W in 2013 in some locations. As previously discussed, achieving $1.00/W across a desired wider geographic domain will be challenging since FP PV is approaching limits in system performance, and module and BOS manufacturing cost reductions.

For PV generation assets placed closer to the end-user, "grid-parity" comparisons must take into account retail vs. wholesale electrical rates, pay-back periods after which the electricity will essentially be free, and enhanced security/independence factors that add value. With that in mind, DOE's SunShot initiative has set a goal of $1.50/W and $1.25/W for residential- and commercial-scale PV, respectively. In 2013, industry data indicates an average installation cost of $3.60-4.00/W[10]. Roughly 80% of that cost is non-module related. Some of that cost is associated with designing in space-constrained markets and where shadowing effects must be included in the performance and cost projections. Higher performing micro-CPV modules, with embedded solar tracking, could provide enhanced energy production in constrained spaces, and provide a path to lowering costs. Preliminary cost estimates for micro-CPV on fixed-tilt rooftops suggest it can meet and surpass the $1.50/W system threshold.

Figure 4 shows the variance of global solar insolation and relative percentage that is due to diffuse radiation for various geographic locations in the contiguous USA. The wide variation in total insolation and diffuse/global ratio is depicted. Currently, CPV is regarded as having potential only in those regions of the US in which the direct component of solar radiation is the highest, i.e., principally the southwestern regions of the USA. ***MOSAIC*** aims to exploit micro-scale CPV technology to expand the geographic regions in which the benefits of CPV may be exploited cost-effectively. In addition, the program seeks to support innovative hybrid concepts that aim to cost-effectively integrate micro-scale CPV to collect Direct Normal Incident (DNI) solar radiation and also to collect the diffuse solar radiation and thereby extend the benefits of CPV to a the widest geographic expanse possible.

[10] http://www.nrel.gov/docs/fy13osti/60207.pdf

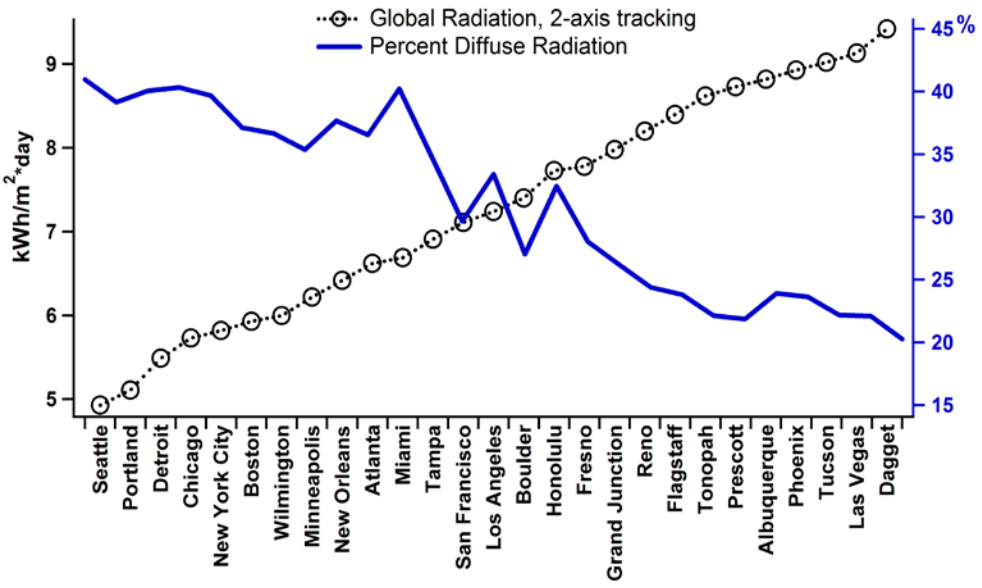

Figure 4. Global insolation and percentage of diffuse radiation as a function of geographical location in the U.S. Data adopted from National Solar Radiation Data Base (1961-1990), 1992

d. Potential Performance Benefits of Micro-Scale CPV

CPV systems use optics to concentrate DNI sunlight onto a smaller solar cell receiver. A particular design will define a collection (aperture) area, a normal dimension over which the light is focused, and a receiver dimension that establishes the size of the solar cell. This design is scalable over several orders of magnitude. Some currently deployed designs have lens and depth dimensions of between 10-100 cm. More recent competing designs have reduced these dimensions to 1-10cm. One-time manufacturing costs, annual operation & maintenance costs, and long-term reliability issues still renders CPV as a challenging choice for project developers. Their bulk, weight, and need for mechanical tracking also render CPV impractical for fixed-position roof-top markets. The micro-scale technology integration sought here significantly extends the current efforts in the CPV community that seek to shrink cell, optics, tracking, and module dimensions. The scalability of micro-systems-based approaches has the potential to remove manufacturing, operational and market barriers to full penetration of CPV.
The potential performance benefits of micro-scale CPV may be considered in terms of scaling with the size of the unit cell in the array. Assuming that a macro-scale CPV module is replaced with an array of N^2 micro-scale concentrators, while keeping the solar energy collection area fixed, then:

- **Mass of optics and module thickness decreases with increasing N,** this lowers Bill of Materials (BOM) and tracker costs, enables a significant module thickness reduction with shorter focal length and enables refractive optics that perform better than Fresnel lenses.

- **Thermal dissipation difficulty scales as 1/N**: For equivalent concentration and total PV cell area, the pixilated micro-CPV approach has a perimeter-to-area ratio that scales as N, thus enhancing thermal dissipation cross the plane. For cell sizes <1mm, the operating temperature approaches 1-Sun levels, removing requirement for heat sinking[11].

- **Wiring degrees-of-freedom scale as N^2:** This enables optimized combining of current and voltage, lowers I^2R losses, minimizes shading effects to avoid by-pass diodes, and enables power conversion closer to the cells, as well as other potential advantages[12].

For non-rooftop applications, micro-CPV modules can employ traditional external tracking mechanisms that are optimized for micro-CPV deployment. Relative to traditional CPV tracking mechanisms, micro-CPV tracking should be substantially lower in cost due to the lower weight and potentially increased angular tolerance of refractive micro-CPV concentrators. For rooftop or similar stationary (fixed-tilt) applications, the ***MOSAIC*** program envisions concentrating optics embedded within the panel with the capability of tracking the sun throughout the day. There are opportunities to exploit micro-scale integration technology in a manner that combines mechanisms by which to capture and convert the direct and diffuse solar radiation within the same integrated structure. Harvesting enhancements from such *hybrid* micro-CPV architectures – which combine micro-CPV elements with low- or no-concentration PV elements – may lead to an expansion of PV into "low-DNI" markets (i.e., those regions to the left of "Reno" in Figure 4). A critical consideration for these options will be the relative cost/benefit of adding additional components necessary to achieve the hybrid functionality.

C. PROGRAM OBJECTIVES

The overall objective of the ***MOSAIC*** Program is to create new technology platforms that will enable the development and deployment of a new class of PV solar harvesting panels based on micro-scale CPV. If successful, ***MOSAIC*** will impact the full range of PV solar-harvesting markets. However, since the first market insertion opportunity that maximizes the potential impact is not yet clear, the ***MOSAIC*** program will focus on addressing a set of key technical challenges from which solutions may be derived for various potential markets.
ARPA-E recognizes that the challenges may differ in type and severity, depending on the specific system architecture and integrated technologies chosen, and the anticipated manufacturing methods that will be required. However, the ***MOSAIC*** program poses four critical challenges common to any proposed solution:

- Micro CPV pixilated cell array fabrication, integration, and packaging techniques;

[11] Gregory N. Nielson ; Murat Okandan ; Jose Luis Cruz-Campa ; Anthony L. Lentine ; William C. Sweatt, et al. "Leveraging scale effects to create next-generation photovoltaic systems through micro- and nanotechnologies", Proc. SPIE 8373, Micro- and Nanotechnology Sensors, Systems, and Applications IV, 837317 (May 1, 2012)
[12] Lentine, A.L.; Nielson, G.N.; Okandan, M.; Cruz-Campa, J.-L.; Tauke-Pedretti, A., "Voltage Matching and Optimal Cell Compositions for Microsystem-Enabled Photovoltaic Modules," Photovoltaics, IEEE Journal, V4,N.6, pp.1593,1602, Nov. 2014

- Micro-scale optics that have high performance, robustness, and manufacturing scalability;
- Micro-optical tracking for fixed-tilt applications; and
- System fabrication costs commensurate with current FP PV.

The challenges listed above cannot be addressed in isolation from each other. In fact the rich micro-scale CPV architecture and technology space may allow many interesting design trade-offs. For example, using lower concentration may increase the cost of the PV material used, but allow simpler and cheaper micro-optics that are more tolerant to tracking errors. Also, some embedded solar tracking mechanisms may be more amenable to certain types of optical elements or actuation methods, or perhaps new solar luminescent concentrator (SLC) designs that use out of band photons could be integrated and add benefits for capturing diffuse light. In short, the best ***MOSAIC*** solutions will involve co-design of the various elements that make up the eventual micro-CPV-based system. Such a *co-optimization* could strike the right balance between the various elements to maximize performance/cost.

Addressing the ***MOSAIC*** technical challenges will require the full exploitation of the degrees-of-freedom afforded by the integration of micro-optical, micro-electrical, and possibly micro-mechanical technologies to enable a transformational advance beyond FP PV performance. New panel system concepts, and the development of new sub-system component technologies, will be needed. It is envisioned that such new micro-CPV technologies will enable a new learning curve for PV that will overcome the performance/cost barriers engendered by current discrete CPV and 1-sun PV technologies.

D. TECHNICAL CATEGORIES OF INTEREST

The ***MOSAIC*** program includes two complete system categories: complete micro-CPV-based system solutions appropriate to two geographical domains in the contiguous U.S. based on the relative percentage of direct and diffuse solar radiation and a third category seeking innovative partial solutions that do not comprise a full system but that attack the critical technology challenges posed above. Each full system category is divided into two sub-categories, corresponding to either a conventional tracking system for the full panel or embedded micro-tracking for fixed-tilt panels. Category 3 seeks innovative partial solutions that address critical aspects of full system solutions in Categories 1 and 2.

Given the rich technology and design space afforded by micro-scale integration, ARPA-E anticipates a wide range of potential micro-CPV solutions that may be considered to address the challenges within the four system sub-categories listed below. It is anticipated that proposed micro-scale CPV solutions will fall in the 10-1000x concentration range. Micro-CPV architectural elements of interest include, but are not limited to: micro-refractive, reflective, or diffractive optical concentrating and/or spectral splitting elements, solar luminescent concentration for diffuse light; tandem and/or lateral PV cell architectures; waveguiding and concentrating structures, including fluorescent concentration; crystalline, thin-film, and multi-

band-gap PV material systems; micro-tracking actuation systems with external or automatic (e.g., using non-linear optical effects) control; micro-actuation systems that operate at the individual CPV cell level, or actuate an entire sub-array; micro-tracking schemes that involve shifting, tilting, deforming the micro-optical elements or PV cells; and tracking micro-optics that employ micro-fluidics, electro-wetting or electro-active polymers.

Category 1: System Solutions for High-DNI Regions

For the purposes of this FOA, a high-DNI region is defined as having annual averaged insolation that is <25% diffuse. With reference to Figure 4, this corresponds generally to portions of the West and Southwestern regions of the USA. In general, micro-CPV-based approaches that do not harvest a significant portion of the smaller diffuse solar component (just like traditional "macro" CPV) are expected to be appropriate to achieve the 30% harvesting target in high-DNI regions. In this case, the critical challenges center on the micro-optical concentration elements and pixilated PV cell arrays, and their integration into a common panel platform.

Subcategory 1A: Micro-scale CPV within a flat panel that may be mounted on conventional tracking systems.

Subcategory 1B: Micro-scale CPV within a flat panel that may be mounted in fixed-tilt applications, such as residential rooftops. Subcategory 1B approaches must therefore include embedded actuation mechanisms within the panel to track the sun as it moves during the day. Micro-tracking approaches may include active control of actuation (requiring some sort of open or closed-loop control and mechanical actuation of the micro-optics/PV unit cells), or passive tracking (e.g., based on some non-linear optical effect within the micro-concentrating optical elements). Tracking may be implemented at the individual micro-CPV cell level or across fixed arrays via shifts or rotations of entire arrays or sub-arrays within the FP structure. Such approaches could include (but are not limited to) micro-mechanical mechanisms, microfluidic-based approaches, electro-wetting lenses, and electro-active polymers.

Category 2: System Solutions for Low-DNI Regions

Low-DNI regions are defined as having annual averaged insolation that is >25% diffuse, corresponding to the remaining portions of the contiguous U.S. shown in Figure 4, which include the heavily populated regions in the upper Midwest and Northeast.
Achieving the aggressive harvesting goal of >30% in these low-DNI regions will require the integration of no- or low-concentration PV elements to capture as much as possible of the relatively larger portions of the diffuse radiation – in combination with the concentrated elements that harvest the direct components. Such hybrid direct/diffuse harvesting approaches will increase the technical and cost challenges, and are therefore relegated to a separate category. Any integrated approaches to capturing the diffuse solar components may be considered, including, but not limited to, solar luminescent concentrators, light trapping films, or the use of conventional FP PV as a substrate to augment the micro-CPV system.

Hybrid direct/diffuse collection solutions may also be appropriate for the high DNI regions of Category 1 (if shown to be cost-effective) as well. Therefore applicants may propose a single hybrid solution that may achieve the goals of both Category 1 and 2 simultaneously, however, ARPA-E does not anticipate that hybrid solutions will be competitive for Category 1 as this additional requirement complicates the design of potential solutions that should prioritize direct radiation.

Subcategory 2A: Micro-scale CPV or hybrid direct/diffuse systems within a flat panel that may be mounted on conventional tracking systems.

Subcategory 2B: Micro-scale CPV or hybrid direct/diffuse systems within a flat panel that may be mounted in fixed-tilt applications, such as residential rooftops. Category 2B approaches must therefore include embedded actuation mechanisms within the panel to track the sun as it moves during the day.

Category 3: Innovative Partial Solutions

This Category seeks innovative partial solutions that address critical aspects, but are not part of a comprehensive solution required in Categories 1 and 2. Areas of specific interest for possible seedling funding include: (1) novel fabrication and integration concepts for pixelated PV cells that achieve high performance and low production costs; and (2) novel micro-optical tracking concentrator concepts that may be integrated with pixelated PV cell arrays. Applications in this category should be presented in the context of a notional full system to represent at least one of the system-level sub-categories described above. Also, to aid in evaluation of a proposed seedling idea, its ability to fit within full solutions should be articulated. For example, in the areas mentioned above, the range of potential cell sizes and pitch should be presented, as well as how cost will be impacted. This category is particularly appropriate for proof-of-concept awards (see Section II.A of the FOA.)

E. TECHNICAL PERFORMANCE TARGETS

MOSAIC sets an aggressive target of >30% harvesting efficiency in both system Categories, but there are some differences in assumptions as explained in the comments following the tables for each the Subcategories below. For example, to facilitate evaluation, the harvesting efficiency goal of 30% is specified for the "worst-case" diffuse percentage in each of the geographic regions associated, i.e., specifying 25% and 40% diffuse solar radiation, for Categories 1 and 2, respectively. Similarly, some of the other metrics are common to Subcategories, but may have differing assumptions or constraints as explained in the comments.

Applicants should use DNI and diffuse data for a geographic location within the high DNI region – available from the technical literature – to analytically characterize and project cumulative energy harvesting performance over an annual cycle. Applicants should estimate the total

annual harvested energy at the output of the module based on an assumed tracking system that operates over the full range of solar angles during the year. It is expected that existing commercial tracking methods will be used (ARPA-E will not fund the development of new tracker concepts under this FOA), but the potentially higher angular acceptance of small optics could simplify the tracking problem somewhat over for current CPV systems.

Subcategory 1A: High-DNI System with Macro-Tracking

ID	Description	Target
1A.1	Solar Energy Harvesting Efficiency	≥ 30% at module output
1A.2	Production Cost	< $125/m^2
1A.3	Array height	< 2.5 cm
1A.4	Projected system degradation	< 1%/year

Subcategory 1B: High-DNI System with Embedded Micro-Tracking

ID	Description	Target
1B.1	Solar Energy Harvesting Efficiency	≥ 30% at module output
1B.2	Production Cost	< $150/m^2
1B.3	Array height	< 2.5 cm
1B.4	Projected system degradation	< 1%/year

Subcategory 2A: Low-DNI System with Macro Tracking

ID	Description	Target
2A.1	Solar Energy Harvesting Efficiency	≥ 30% at module output
2A.2	Production Cost	< $150/m^2
2A.3	Array height	< 2.5 cm
2A.4	Projected system degradation	< 1%/year

Subcategory 2B: Low-DNI System with Embedded Micro-Tracking

ID	Description	Target
2B.1	Solar Energy Harvesting Efficiency	≥ 30% at module output
2B.2	Production Cost	< $175/m^2
2B.4	Array height	< 2.5 cm
2B.5	Projected system degradation	< 1%/year

Explanations of Technical Targets:

Harvesting Efficiency (IDs : 1A.1, 1B.1, 2A.1, and 2B.1):

The harvesting targets corresponds to the percentage of global annual average radiation converted to electrical DC power out of the panel, assuming: 25% of total insolation is diffuse for the High-DNI case in Category 1; and 40% of total insolation is diffuse for the Low-DNI case in Category 2. The overall projected module system efficiency that is a combination of the anticipated PV conversion efficiency, micro-optics efficiency, and the

efficiency effects of harvesting power from the pixilated PV cells should be described. Applications should show how the wiring complexity afforded by micro-scale PV array may be exploited to enhance energy yield. The efficiency with which the proposed architecture captures solar energy during tracking should be described in terms of all of the critical elements. For example, in Category 1A, the tolerance of the micro-CPV system to macro-tracking imperfections as it may relate to, e.g., acceptance angle, should be included.

Production Costs (IDs: 1A.2, 1B.2, 2A.2, and 2B.2):

The aggressive target for 1A.2 assumes economies-of-scale associated with very large scale production similar to current FP PV. The need to integrate micro-tracking for the fixed-tilt category 1B will engender higher costs, hence the elevated cost target for 1B.2. The need for a hybrid micro-CPV/diffuse harvesting solution in Subcategory 2A also will engender a higher cost target as shown. Lastly, Subcategory 2B requires both embedded micro-tracking and the integration of micro-CPV with diffuse solar harvesting in a hybrid configuration – and thus has the highest production cost target.

Array Height (IDs: 1A.3, 1B.3, 2A.3, and 2B.3):

There are practical considerations and limitations of how small the unit cell in a micro-CPV system might be. ARPA-E is seeking solutions where the total module thickness is consistent with current flat panel PV profiles – hence the total height of the ***MOSAIC*** modules is limited to <2.5 cm. The module thickness will determine other related parameters, depending on concentration levels, such as density of cell placement, aperture lens dimension, etc.

Degradation (IDs: 1A.4, 1B.4, 2A.4, and 2B.4):

Current high-performing FP PV systems are extremely robust to normal environmental and operational degradation – and achieve 1% or less degradation per year. The ***MOSAIC*** target is set to match this level of robustness in order to ensure that ***MOSAIC*** technology is a competitive option in future deployments.

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 Section I.E of the FOA
- Applications that have been submitted in response to other currently issued ARPA-E FOAs.
- Applications that are not scientifically distinct from applications submitted in response to other currently issued ARPA-E FOAs.
- Applications for basic research aimed solely at discovery and/or 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 for proposed technologies that are not transformational, as described in Section I.A of the FOA and as illustrated in Figure 1 in Section I.A of the FOA.
- 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 scientifically distinct from existing funded activities supported elsewhere, including within the Department of Energy.
- Applications that propose the following:
    - non-PV solutions (e.g., concentrated solar thermal or thermal-electric solutions),
    - 1-sun (non-concentrated) solutions.
    - PV to be deployed in space, or on balloons or towers.

II. AWARD INFORMATION

A. AWARD OVERVIEW

ARPA-E expects to make approximately $15 million available for new awards under this FOA, subject to the availability of appropriated funds. ARPA-E anticipates making approximately 4 to 8 awards under this FOA. ARPA-E may issue one, multiple, or no awards.

Individual awards may vary between $250,000 and $10 million.

The period of performance for funding agreements may not exceed 36 months. ARPA-E expects the start date for funding agreements to be October 2015, or as negotiated.

ARPA-E encourages applications stemming from ideas that still require proof-of-concept R&D efforts as well as those for which some proof-of-concept demonstration already exists.

Applications requiring proof-of-concept R&D can propose a project with the goal of delivering on the program metric at the conclusion of the project period. Such applications are particularly relevant for Category 3, Innovative Partial Solutions. These applications should contain an appropriate cost and project duration plan that is described in sufficient technical detail to allow reviewers to meaningfully evaluate the proposed project. If awarded, such projects should expect a rigorous go/no-go milestone early in the project associated with the proof-of-concept demonstration. Alternatively, applications requiring proof-of-concept R&D can propose a project with the project end deliverable being an extremely creative, but partial solution. However, the Applicants are required to provide a convincing vision how these partial solutions can enable the realization of the program metrics with further development.

Applicants proposing projects for which some initial proof-of-concept demonstration already exists should submit concrete data that supports the probability of success of the proposed project. Applicants should identify the highest risk elements in their proposed project and set milestones based on those risks, as well as identify risk mitigation strategies.

ARPA-E will provide support at the highest funding level only for applications with significant technology risk, aggressive timetables, and careful management and mitigation of the associated risks.

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 plans to fully fund your negotiated budget at the time of award.

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."[13] 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.[14]

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/arpa-e-site-page/award-guidance.

[13] U.S. Congress, Conference Report to accompany the 21st Century Competitiveness Act of 2007, H. Rpt. 110-289 at 171-172 (Aug. 1, 2007).
[14] The Prime Recipient is the signatory to the funding agreement with ARPA-E.

2. FUNDING AGREEMENTS WITH FFRDCS, GOGOS, AND FEDERAL INSTRUMENTALITIES[15]

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

When a FFRDC is a *member* of a Project Team, ARPA-E generally 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 Prime Recipient under the Cooperative Agreement is the lead organization for the entire project, including all work performed by the FFRDC 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 will have substantially similar terms and conditions as ARPA-E's Model Cooperative Agreement (http://arpa-e.energy.gov/arpa-e-site-page/award-guidance).

Non-DOE GOGOs and Federal agencies may be proposed as supporting project team members on an applicant's project. The Non-DOE GOGO/Agency support would be obtained via an Interagency Agreement between ARPA-E and the non-DOE GOGO/Agency, and provided as part of ARPA-E's standard substantial involvement in its funded projects.

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.

[15] DOE/NNSA GOGOs are not eligible to apply for funding, as described in Section III.A of the FOA.

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.

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 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 and Prime Recipients mutually 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/arpa-e-site-page/award-guidance). 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 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

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.

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,[16] as the lead for a Project Team,[17] or as a member of a Project Team.

2. DOMESTIC ENTITIES

For-profit entities, educational institutions, and nonprofits[18] 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.

[16] A Standalone Applicant is an Applicant that applies for funding on its own, not as part of a Project Team.

[17] 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.

[18] 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.

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 United States (including U.S. territories). The Applicant may request a waiver of this requirement in the Business Assurances & Disclosures Form, which is submitted with the Full Application. Please refer to the Business Assurances & Disclosures 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 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[19]

Applicants are bound by the cost share proposed in their Full Applications.

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[20] as cost share, except as provided in Sections III.B.2 or III.B.3 below.[21]

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 when selecting applications for award negotiations (see Section V.B.1 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.

- Small businesses – or consortia of small businesses - will provide 0% cost share from the outset of the project through the first 12 months of the project (hereinafter the "Cost Share Grace Period"). If the project is continued beyond the Cost Share Grace Period, then at least 10% of the Total Project Cost (including the costs incurred during the Cost Share Grace Period) will be required as cost share over the remaining period of performance.

- Project Teams where a small business is the lead organization and small businesses perform greater than or equal to 80%, but less than 100%, of the total work under

[19] Please refer to Section VI.B.3-4 of the FOA for guidance on cost share payments and reporting.
[20] 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 and FFRDCs.
[21] Energy Policy Act of 2005, Pub.L. 109-58, sec. 988.

the funding agreement (as measured by the Total Project Cost) the Project Team are entitled to the same cost share reduction and Cost Share Grace Period as provided above to Standalone small businesses or consortia of small businesses.

- 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.

- 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.

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[22] 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 Contracting Officer and incorporated into the project budget before the expenditures are incurred.

[22] As defined in Federal Acquisition Regulation Section 31.205-18.

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 are funded by the Federal Government, costs incurred by FFRDCs 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.

Because GOGOs/Federal Agencies are funded by the Federal Government, GOGOs/Federal Agencies may not provide cost share for the proposed project. However, the GOGO/Agency costs would be included in Total Project Costs for purposes of calculating the cost-sharing requirements of the applicant.

8. COST SHARE VERIFICATION

Upon selection for award negotiations, Applicants are required to provide 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. 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.F of the FOA, are deemed nonresponsive and are not reviewed or considered.

3. LIMITATION ON NUMBER OF APPLICATIONS

Small businesses that qualify as "Small Business Concerns" are strongly encouraged to apply under ARPA-E FOA DE-FOA-0001256 (SBIR/STTR), Micro-Scale Optimized Solar-Cell Arrays With Integrated Concentration (***MOSAIC***). To determine eligibility as a "Small Business Concern" under

DE-FOA-0001256, please review the eligibility requirements in Sections III.A-III.D of DE-FOA-0001256 (SBIR/STTR), available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).

Small businesses that qualify as a "Small Business Concern" may apply to only one of the *MOSAIC* FOAs.

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 in Section V.A.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 non-compliant.

5. PRE-SELECTION CLARIFICATIONS AND "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, conduct a pre-selection clarification process and/or perform a "down-select" of Full Applications. Through the pre-selection clarification process or down-select process, 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. The Selection Official may select or not select a Full Application for award negotiations. The Selection Official 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, and Business Assurances & Disclosures Form. A sample response to the Business Assurances & Disclosures 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 Summary Slide, the template for the Summary for Public Release, and the template for the Reply to Reviewer Comments.

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 and Summary Slide must have been submitted) and must conform to the following formatting requirements:

- The Concept Paper must not exceed 4 pages in length including graphics, figures, and/or tables.
- The Summary Slide may not exceed 1 page in length.
- The Concept Paper must be submitted in Adobe PDF format.
- The Summary Slide must be submitted in Microsoft PowerPoint format.
- The Concept Paper and Summary Slide 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. Single space all text and use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures and tables).

- The ARPA-E assigned Control Number, the Lead Organization Name, and the Principal Investigator's Last Name 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.

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

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

1. CONCEPT PAPER

a. CONCEPT SUMMARY

- Describe the proposed concept with minimal jargon, and explain how it addresses the Program Objectives of the FOA.

b. INNOVATION AND IMPACT

- Clearly identify the problem to be solved with the proposed technology concept.

- Describe how the proposed effort represents an innovative and potentially transformational solution to the technical challenges posed by the FOA.

- Explain the concept's potential to be disruptive compared to existing or emerging technologies.

- To the extent possible, provide quantitative metrics in a table that compares the proposed technology concept to current and emerging technologies and to the technical

performance targets in Section I.E of the FOA for the appropriate Technology Category in Section I.D of the FOA.

c. PROPOSED WORK

- Describe the final deliverable(s) for the project and the overall technical approach used to achieve project objectives.

- Discuss alternative approaches considered, if any, and why the proposed approach is most appropriate for the project objectives.

- Describe the background, theory, simulation, modeling, experimental data, or other sound engineering and scientific practices or principles that support the proposed approach. Provide specific examples of supporting data and/or appropriate citations to the scientific and technical literature.

- Describe why the proposed effort is a significant technical challenge and the key technical risks to the project. Does the approach require one or more entirely new technical developments to succeed? How will technical risk be mitigated?

- Identify techno-economic challenges to be overcome for the proposed technology to be commercially relevant.

d. TEAM ORGANIZATION AND CAPABILITIES

- Indicate the roles and responsibilities of the organizations and key personnel that comprise the Project Team.

- Provide the name, position, and institution of each key team member and describe in 1-2 sentences the skills and experience that he/she brings to the team.

- Identify key capabilities provided by the organizations comprising the Project Team and how those key capabilities will be used in the proposed effort.

- Identify (if applicable) previous collaborative efforts among team members relevant to the proposed effort.

2. SECOND COMPONENT: SUMMARY SLIDE

Applicants are required to provide a single PowerPoint slide summarizing the proposed project. This slide will be used during ARPA-E's evaluation of Concept Papers. A summary slide template

and a sample summary slide are available on ARPA-E eXCHANGE (https://arpae-foa.energy.gov). Summary Slides must conform to the content requirements described below:

- Project Title;
- Lead Organization, Principal Investigator, and key personnel names;
- ARPA-E Assigned Control Number;
- Technical Category;
- Estimated Total Project Cost;
- Technology Summary and Impact;
    - Bullet points that describe novel aspects of the technology, approach, and impact on the ***MOSAIC*** Program goals;
- Proposed Goals;
    - Including any important technical performance metrics;
    - Including quantitative description of the state of the art; and
    - Including quantitative descriptions of the proposed targets;
- Any key graphics (e.g., illustrations, charts and/or tables that summarize the technology, key innovations, and planned approach);

3. ADDITIONAL INSTRUCTIONS

- Applicants may propose a single hybrid direct/diffuse harvesting solution that may achieve the goals of Categories 1 and 2 simultaneously. However, ARPA-E does not anticipate that such hybrids will be competitive for Category 1 alone as hybridization complicates the design of potential solutions that should prioritize direct radiation.

- Category 3 submissions should be presented in the context of a notional full system to represent at least one of the system-level sub-categories described in Section I.D of the FOA. Also, to aid in evaluation of a proposed seedling idea, its ability to fit within full solutions should be articulated. For example, in the areas mentioned in Section I.D of the FOA, the range of potential cell sizes and pitch should be presented, as well as how cost will be impacted.

D. CONTENT AND FORM OF FULL APPLICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]

E. CONTENT AND FORM OF REPLIES TO REVIEWER COMMENTS

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]

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 MARCH 2015]

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 received 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 FOA Targets* (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 compared to existing or emerging technologies;

- The extent to which the proposed concept is innovative and will achieve the technical performance targets defined in Section I.E of the FOA for the appropriate technology Category in Section I.D of the FOA; 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 feasibility of the proposed work, as justified by appropriate background, theory, simulation, modeling, experimental data, or other sound scientific and engineering practices;

- The extent to which the Applicant proposes a sound technical approach to accomplish the proposed R&D objectives, including why the proposed concept is more appropriate than alternative approaches and how technical risk will be mitigated;

- The extent to which project outcomes and final deliverables are clearly defined;

- The extent to which the Applicant identifies techno-economic challenges that must be overcome for the proposed technology to be commercially relevant; and

- The demonstrated capabilities of the individuals performing the project, the key capabilities of the organizations comprising the Project Team, the roles and responsibilities of each organization and (if applicable) previous collaborations among team members supporting the proposed project.

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 FOA Targets	50%
Overall Scientific and Technical Merit	50%

2. CRITERIA FOR FULL APPLICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]

3. CRITERIA FOR REPLIES TO REVIEWER COMMENTS

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]

B. REVIEW AND SELECTION PROCESS

1. PROGRAM POLICY FACTORS

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]

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 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 MARCH 2015]

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. REJECTED SUBMISSIONS

Noncompliant and nonresponsive Concept Papers and Full Applications are rejected by the Contracting Officer and are not reviewed or considered. The 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. ARPA-E provides feedback in the notification letter in order to guide further development of the proposed technology.

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. 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 MARCH 2015]

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]

C. REPORTING

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2015]

VII. AGENCY CONTACTS

A. COMMUNICATIONS WITH ARPA-E

Upon the issuance of a FOA, only the Contracting Officer may communicate with Applicants. ARPA-E personnel and our support contractors 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 Contracting Officer may authorize communications between ARPA-E personnel and Applicants. The Contracting Officer may communicate with Applicants as necessary and appropriate. As described in Section IV.A of the FOA, the 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 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 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 & Disclosures 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.

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 satisfactory manner;
- The owner has not met public use requirements specified by Federal statutes in a reasonably 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).

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

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.

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.

Small Business Concern: A for-profit entity that: (1) maintains a place of business located in the United States; (2) operates primarily within the United States or makes a significant

contribution to the United States economy through payment of taxes or use of American products, materials or labor; (3) is an individual proprietorship, partnership, corporation, limited liability company, joint venture, association, trust, or cooperative; and (4) meets the size eligibility requirements set forth in 13 C.F.R. § 121.702. Where the entity is formed as a joint venture, there can be no more than 49% participation by foreign business entities in the joint venture.

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 GOGOs and FFRDCs.

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