PMC-EF2a

(2.06.02)

U.S. DEPARTMENT OF ENERGY
EERE PROJECT MANAGEMENT CENTER
NEPA DETERMINATION

RECIPIENT: NREL

STATE: CO

PROJECT TITLE : Low Cost Arc-Fault Detection and Protection for PV Systems-Tigo Energy, Inc.; NREL Tracking No. 11-029

Funding Opportunity Announcement Number	Procurement Instrument Number	NEPA Control Number	CID Number
		NREL-11-029	GO10337

Based on my review of the information concerning the proposed action, as NEPA Compliance Officer (authorized under DOE Order 451.1A), I have made the following determination:

CX, EA, EIS APPENDIX AND NUMBER:

Description:

A9

Information gathering (including, but not limited to, literature surveys, inventories, audits), data analysis (including computer modeling), document preparation (such as conceptual design or feasibility studies, analytical energy supply and demand studies), and dissemination (including, but not limited to, document mailings, publication, and distribution; and classroom training and informational programs), but not including site characterization or environmental monitoring.

B5.15 Small-scale renewable energy research and development and pilot projects

Small-scale renewable energy research and development projects and small-scale pilot projects, provided that the projects are located within a previously disturbed or developed area. Covered actions would be in accordance with applicable requirements (such as local land use and zoning requirements) in the proposed project area and would incorporate appropriate control technologies and best management practices.

B3.11 Outdoor tests and experiments on materials and equipment components

Outdoor tests and experiments for the development, quality assurance, or reliability of materials and equipment (including, but not limited to, weapon system components) under controlled conditions. Covered actions include, but are not limited to, burn tests (such as tests of electric cable fire resistance or the combustion characteristics of fuels), impact tests (such as pneumatic ejector tests using earthen embankments or concrete slabs designated and routinely used for that purpose), or drop, puncture, water-immersion, or thermal tests. Covered actions would not involve source, special nuclear, or byproduct materials, except encapsulated sources manufactured to applicable standards that contain source, special nuclear, or byproduct materials may be used for nondestructive actions such as detector/sensor development and testing and first responder field training.

Rational for determination:

BACKGROUND

The SunShot Incubator project represents a significant component of the U.S. Department of Energy (DOE) business strategy of partnering with U.S. industry to accelerate the commercialization of solar energy system research and development (R&D) to meet aggressive cost and installed capacity goals. This specific partnership leverages technical capabilities and resources within the National Renewable Energy Laboratory (NREL) and other DOE laboratories/facilities to enhance and support areas of expertise within a small business in order to accelerate the development of the small business's technology. This early-stage assistance in crossing the technological barriers to commercialization also provides a better level of understanding and development for the investment community to base decisions on.

The Subcontractor for this proposed project is Tigo Energy, Inc. (Tigo) of Los Gatos, CA and the proposed project duration is 18 months. The objective of the proposed project would be to advance to the pilot production of an innovative and low-cost DC arc-fault detector which would enhance the safety of photovoltaic arrays, reduce ongoing operating and maintenance (O&M) costs for system owners, and comply with all applicable codes and standards for new and retrofit applications in residential, commercial, and utility-scale systems. The outcome would be to develop an off-the-shelf ASIC arc-fault detector. This would be built from an existing prototype arc-fault detection device using discrete components and laboratory equipment as the starting point for the project. The intermediary objective would be to build a working prototype utilizing a field programmable gate array (FPGA). The final objective would be to implement a cost reduction of the device by incorporating a mixed-signal ASIC-based technology to provide the communications interface for the detector circuit.

PROPOSED ACTION

Work would be conducted in two phases, four tasks, and multiple subtasks as discussed below over a 18-month period:

PHASE I
Phase I of the proposed project would involve development of a field programmable gate array (FPGA)-based arc-fault detection and protection solution.

Task 1 - FPGA Beta Prototype Arc-Fault Detector

Subtask 1.1 – Prototype Verification
The Subcontractor would demonstrate a working alpha-version prototype arc fault detector (AFD) and arc generator. The Subcontractor would perform additional testing to confirm the functionality of the AFD in a large-scale PV system. This effort is expected to demonstrate the effectiveness of the alpha-version prototype to detect and respond to arc faults both in a laboratory situation and installed in a working PV array.

Subtask 1.2 – Design & Development
The Subcontractor would develop a printed circuit board (PCB) layout for the FPGA prototype arc-fault detector (AFD), with all components placed on the printed circuit board and wiring connections created between the components. Reliability would be ensured by selecting components suitable for the temperatures associated with rooftop PV systems. The Subcontractor would specify and source all components to meet performance, reliability, and cost targets. The Subcontractor would focus on several key components from the alpha prototype that have been identified for replacement including the DC coupling transformer and the analog-to-digital converter (ADC). Additionally, the Subcontractor would develop software to implement an industry-standard protocol to allow bi-directional communication between the AFD and an external device. This effort is expected to result in the delivery of a new PCB design which would provide the same functionality and performance as the alpha prototype device.

Subtask 1.3 – Integration & Packaging
The Subcontractor would assemble the printed circuit boards (hardware) and program the FPGA and embedded processor (software). The Subcontractor would develop an enclosure for the FPGA-based printed-circuit board that enables the use of the AFD in either a standalone mode or mounted inside a combiner box, using standard mounting hardware and methods. The Subcontractor would then test the PCB assembly for functionality. The Subcontractor would verify that the AFD device requires less than 2.5 W power during operation, and would verify that the communications interface permits full bi-directional communications capability. This effort is expect to result in a functional PCB assembly and mating enclosure.

Task 2 - Technically Viable FPGA-Based Arc-Fault Detector

Subtask 2.1 – Optimization & Evaluation
The Subcontractor would fine-tune the signal processing algorithm to address functional and performance issues that may be found in lab or field testing. The subcontractor would also continue refinements in embedded software, fine-tuning of the detection algorithms, and addition of new features to ensure compliance with the draft UL 1699B standard requirement updates as they are developed. The Subcontractor would produce a limited number of fully-assembled arc fault detectors using the PCB assembly and the early production of the enclosure. The Subcontractor would test the fully-assembled AFDs for functionality. This effort is expected to result in a limited production run of fully-assembled FPGA-based arc-fault detectors that would be suitable for further testing.

Subtask 2.2 – Compliance & Reliability
The Subcontractor would submit the assembled FPGA-based arc-fault detector to an independent, nationally-recognized testing laboratory (NRTL) for compliance testing and certification. The standard to which the AFD would be tested is UL1699B, "Draft outline of investigation for photovoltaic (PV) DC arc-fault circuit protection," version December 16, 2010, published by Underwriters Laboratories, Inc. The Subcontractor would submit the assembled FPGA-based arc-fault detector to a third-party testing laboratory for accelerated stress testing, including highly-accelerated lifetime testing (HALT) and highly accelerated stress screening (HASS). The successful results of these tests would predict that the FPGA-based AFD has a lifetime of not less than 25 years under the rooftop environment of a PV array. This effort is expected to result in an FPGA-based arc-fault detector which would be certified and listed by a nationally-recognized testing laboratory, and which would have an expected lifetime of at least 25 years.

Subtask 2.3 – Demonstration & Validation
The Subcontractor would commence PV system field tests at five existing sites. The sites would be selected based on their size, location, and availability, and would provide a representative sampling of typical rooftop PV arrays. The sites would include at least one small residential system consisting of a single string of PV modules with an inverter size less than 5 kW, and a large commercial system consisting of up to 85 parallel strings connected through various combiner boxes into a central inverter of at least 250 kW. All field tests would be continuously monitored by collecting and analyzing data from every module at a 2-second sampling interval. This effort is expected to result in the identification of engineering change orders to improve the functionality, reliability, and manufacturability of the FPGA-based arc-fault detector.

Subtask 2.4 – Production Line Development
The Subcontractor would establish a final assembly and test location in the U.S. for production of the arc fault

detector. The Subcontractor would establish a pilot line operation in the U.S. and set up a quality-control system. The Subcontractor would monitor all the final assembly and final test steps and optimize production processes with the main goal of reducing cycle time to drive down costs and improve production yield. The Subcontractor would develop and implement a certified ISO-9002 quality-control system in this facility. The Subcontractor would initiate volume pilot production of the FPGA arc-fault detector and initiate the quality-control system. This effort is expected to result in a new production and test facility that employs industry-standard quality-control procedures.

Phase II
Phase II of this subcontract would address cost and size reduction of the arc detection product by replacing the FPGA used in Phase I with a mixed-signal communications ASIC.

Task 3 - ASIC-Based Prototype Arc-Fault Detector
The Subcontractor would use their FPGA-based arc-fault detector as a baseline to develop a beta version using a new ASIC design.

Subtask 3.1 – Field Test Analysis
The Subcontractor would evaluate the results of the five field tests of the FPGA-based arc-fault detector. The Subcontractor would fully analyze and understand any unexpected behavior, particularly any false positive detections of an arc fault, and use this information to improve the detection algorithms. The Subcontractor would extrapolate the tests to determine the expected false alarm rate, which should be less than one false alarm for a 1 MW (or equivalent) PV array during a three-year period. This effort is expected to demonstrate the effectiveness of the FPGA-based AFD, and to confirm its low false-alarm rate.

Subtask 3.2 – Design & Development
The Subcontractor would develop a printed circuit board (PCB) layout for the ASIC prototype arc-fault detector (AFD), with all components placed on the printed circuit board and wiring connections created between the components. Reliability would be ensured by selecting components suitable for the temperatures associated with rooftop PV systems. The Subcontractor would specify and source all components to meet performance, reliability, and cost targets. This effort is expected to result in the delivery of a new PCB design which would provide the same functionality and performance as the FPGA-based arc-fault detection device.

Subtask 3.3 – Integration & Packaging
The Subcontractor would assemble the printed circuit boards (hardware) and program the ASIC and embedded processor (software). The Subcontractor would develop an enclosure for the ASIC-based printed-circuit board that enables the use of the AFD in either a standalone mode or mounted inside a combiner box, using standard mounting hardware and methods. The Subcontractor would then test the PCB assembly for functionality. The Subcontractor would verify that the AFD device requires less than 0.5 W power during operation, and would verify that the communications interface permits full bi-directional communications capability. This effort is expect to result in a functional PCB assembly and mating enclosure.

Task 4 – ASIC-Based Arc-Fault Detector Product
The Subcontractor would optimize and evaluate the ASIC-based arc-fault detector.

Subtask 4.1 – Optimization & Evaluation
The Subcontractor would fine-tune the signal processing algorithm to address functional and performance issues that may be found in lab or field testing. The subcontractor would also continue refinements in embedded software, fine-tuning of the detection algorithms, and addition of new features to ensure compliance with the draft UL 1699B standard requirement updates as they are developed. The Subcontractor would produce a limited number of fully-assembled arc fault detectors using the PCB assembly and the early production of the enclosure. The Subcontractor would test the fully-assembled AFDs for functionality. This effort is expected to result in a limited production run of fully-assembled ASIC-based arc-fault detectors that would be suitable for further testing.

Subtask 4.2 – Compliance & Reliability
The Subcontractor would submit the assembled ASIC-based arc-fault detector to an independent, nationally-recognized testing laboratory (NRTL) for compliance testing and certification. The standard to which the AFD would be tested is UL1699B, "Draft outline of investigation for photovoltaic (PV) DC arc-fault circuit protection," version December 16, 2010, published by Underwriters Laboratories, Inc. The Subcontractor would submit the assembled ASIC-based arc-fault detector to a third-party testing laboratory for accelerated stress testing, including highly-accelerated lifetime testing (HALT) and highly accelerated stress screening (HASS). The successful results of these tests would predict that the ASIC-based AFD has a lifetime of not less than 25 years under the rooftop environment of a PV array. This effort is expected to result in an ASIC-based arc-fault detector which would be certified and listed by a nationally-recognized testing laboratory, and which would have an expected lifetime of at least 25 years.

Subtask 4.3 – Demonstration & Validation
The Subcontractor would commence PV system field tests at five sites. The sites would be selected based on their size, location, and availability, and would provide a representative sampling of typical rooftop PV arrays. The sites

would include at least one small residential system consisting of a single string of PV modules with an inverter size less than 5 kW, and a large commercial system consisting of up to 85 parallel strings connected through various combiner boxes into a central inverter of at least 250 kW. All field tests would be continuously monitored by collecting and analyzing data from every module at a 2-second sampling interval. This effort is expected to result in the identification of engineering change orders to improve the functionality, reliability, and manufacturability of the ASIC-based arc-fault detector.

Subtask 4.4 – Production Deployment
The Subcontractor would establish a final assembly and test location in the U.S. for production of the arc fault detector. The Subcontractor would establish a pilot line operation in the U.S. and set up a quality-control system. The Subcontractor would monitor all the final assembly and final test steps and optimize production processes with the main goal of reducing cycle time to drive down costs and improve production yield. The Subcontractor would develop and implement a certified ISO-9002 quality-control system in this facility. The Subcontractor would initiate volume pilot production of the ASIC-based arc-fault detector and initiate the quality-control system. This effort is expected to result in a new production and test facility that employs industry-standard quality-control procedures.

IMPACTS OF PROPOSED ACTION
All work proposed to be conducted by the Subcontractor, except Subtask 2.4 and Subtask 4.4, would occur at Tigo's existing facility in Los Gatos, California; field testing at existing PV installations; or third-party reliability and certification testing at existing laboratories. Tigo Energy is located at 420 Blossom Hill Road, Los Gatos, California. This facility is currently used for office space, engineering laboratories, and light manufacturing. None of the proposed work would be different from work already taking place at this location. Only nominal amounts of chemicals would be used and stored by Tigo Energy. Following the Tigo Energy safety plan, all chemicals and hazardous materials would be designated and stored in locked areas. Material safety data sheets would be available to all employees. Disposal of hazardous materials would be handled according to all applicable requirements. These internal procedures would also apply to the proposed project.

Prototypes would be tested at several field sites under Subtasks 2.3 and 4.3, with the locations to be determined. This field testing would occur at existing PV array installations at a variety of scales. This effort would not require any additional infrastructure, excavation, utilization of hazardous materials, etc. Fully assembled arc fault detectors would be temporarily added to the existing electrical infrastructure following proper safety protocols. No environmental impacts of these tasks are anticipated.

The proposed project, except Subtasks 2.4 and 4.4, would occur in previously disturbed or developed areas. All other Subtasks are not anticipated to impact endangered or threatened species, critical habitat, other protected species, historic and cultural resources, floodplains, wetlands, or prime farmlands. The Tigo Energy facility in Los Gatos, California is located in a Coastal Management Zone, however the types of activities proposed (except potentially Subtasks 2.4 and 4.4) would not require a Coastal Zone Consistency Determination. The proposed project (excluding Subtasks 2.4 and 4.4) would not require any additional federal, state, or local permits, or result in the emission of air pollutants above de minimis thresholds. As the locations of manufacturing facilities in Subtasks 2.4 and 4.4 are unknown, potential impacts to critical resources cannot be analyzed at this time. Subtasks 2.4 and 4.4 will need to be evaluated for potential impacts at a later date as discussed below.

NEPA DETERMINATION
Based upon the information above, Subtasks 1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 4.1, 4.2, and 4.3 qualify for Categorical Exclusions A9, B3.11, and B5.15. Subtasks 2.4 and 4.4 are conditioned under NEPA until additional information is provided. Once the proposed locations of manufacturing activities described in Subtasks 2.4 and 4.4 are known, the Subcontractor shall submit Environmental Checklists for each proposed facility and associated activities.

NEPA PROVISION

DOE has made a conditional NEPA determination for this award, and funding for certain tasks under this award is contingent upon the final NEPA determination.

Insert the following language in the award:

You are restricted from taking any action using federal funds, which would have an adverse affect on the environment or limit the choice of reasonable alternatives prior to DOE/NNSA providing either a NEPA clearance or a final NEPA decision regarding the project.

Prohibited actions include:
Enaging in any activities specified in the Appendix A-1 Statement of Work dated September 20, 2011 for Subtasks 2.4 and 4.4, including but not limited to the establishment of a final assembly and test location in the U.S. for production of arc fault detector.
This restriction does not preclude you from:
Enaging in all activities specified in the Appendix A-1 Statement of Work dated September 20, 2011 for Subtasks 1.1,

1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 4.1, 4.2, and 4.3.
If you move forward with activities that are not authorized for federal funding by the DOE Contracting Officer in advance of the final NEPA decision, you are doing so at risk of not receiving federal funding and such costs may not be recognized as allowable cost share.

Note to Specialist :

EF2a prepared by Rob Smith on 11/29/11.

SIGNATURE OF THIS MEMORANDUM CONSTITUTES A RECORD OF THIS DECISION.

NEPA Compliance Officer Signature: Lori Gray Lori Gray Date: 11/29/2011
NEPA Compliance Officer

FIELD OFFICE MANAGER DETERMINATION

☐ Field Office Manager review required

NCO REQUESTS THE FIELD OFFICE MANAGER REVIEW FOR THE FOLLOWING REASON:

☐ Proposed action fits within a categorical exclusion but involves a high profile or controversial issue that warrants Field Office Manager's attention.
☐ Proposed action falls within an EA or EIS category and therefore requires Field Office Manager's review and determination.

BASED ON MY REVIEW I CONCUR WITH THE DETERMINATION OF THE NCO :

Field Office Manager's Signature: _____ Date: _____
Field Office Manager