U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Procurement Specifications Templates for Onsite Solar Photovoltaic: For Use in Developing Federal Solicitations

Prepared for the U.S. Department of Energy Federal Energy Management Program

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April 2020

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Acknowledgements

This document has been published with the support of Andy Walker, Otto VanGeet, Tom Harris and Chandra Shah of the National Renewable Energy Laboratory (NREL).

Disclaimer

The enclosed technical template language is intended to provide only example language for agencies to consider in the process of assembling a solicitation and ultimately a contract for privately financed on site solar photovoltaic (PV) systems. Agency contract officers, attorneys, and engineers are responsible for determining the final content of any solicitation. Updated to the regulations, codes, and standards applicable to solar PV are changing frequently; it is the responsibility of agency managers to determine which guidelines (and which versions) apply.

Feedback and Suggestions Welcomed: FEMPTA@ee.doe.gov

Revision History

Revision History		
Revision	**Date**	**Reason**
1.1	September 2015	First Draft
1.2	December 2015	Second Draft
1.3	September 2016	Third Draft – DOE-OGC Review
1.4	December 2016	DOE Solar Office Review
1.5	January 2017	Final Draft

Abbreviations and Acronyms

A-E	architectural and engineering
AC	alternating current
ACI	American Concrete Institute
ADA	American with Disabilities Act
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
CAD	computer-aided design
CD	compact disc
COTR	Contracting Officer’s Technical Representative
CPI	Consumer Price Index
CT	current transducer
DAS	data acquisition system
DC	direct current
EE	Electrical Engineer
EISA	Energy Independence and Security Act
EMI	electromagnetic interference
EN	European Standard
ESPC	energy savings performance contract
EV	electric vehicle
FAA	Federal Aviation Administration
FAR	Federal Acquisition Regulation

FCC	Federal Communications Commission
FEMP	Federal Energy Management Program
HVAC	heating, ventilation, and air conditioning
IBC	International Building Code
ICC	International Code Council
IDA	International Dark-Sky Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IMC	International Mechanical Code
IPC	International Plumbing Code
ISO	International Organization for Standardization
ksi	kilopounds per square inch
kW	kilowatt
kWh	kilowatt-hour
LED	light-emitting diode
LFRT	low-frequency ride through
LVRT	low-voltage ride through
M&V	measurement and verification
NABCEP	North American Board of Certified Energy Practitioners
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NETA	International Test Association

NREL	National Renewable Energy Laboratory
NRTL	Nationally Recognized Testing Laboratory
OSHA	Occupational Safety and Health Administration
PID	Potential-Induced Degradation
PPA	power purchase agreement
PV	photovoltaic
PVQAT	PV Quality Assurance Task Force
QP	Qualification Plus
RCD	residual current detector
RFP	request for proposals
SAM	system advisor model
SEAOC	Structural Engineers Association of California
SGHAT	Solar Glare Hazard Analysis Tool
SHPO	State Historic Preservation Offices
SOW	statement of work
STC	standard test conditions
TOU	time-of-use
UCF	Uniform Contract Format
UESC	Utility Energy Services Contracts
UL	Underwriters Laboratories
VAR	volt-amperes reactive
WCPR	Weather-Corrected Performance Ratios

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Executive Summary

With the increasing adaption of renewable energy systems onsite, designed to feed site loads, there is a critical need to develop tools that allow the federal sector to become a mature and sophisticated consumer. The core intent of this document is to reduce project development and operational risks while increasing the speed at which projects are completed; two necessary components to reach the scale required to meet mandates and achieve cost savings for taxpayers. This guide is intended to act as a living document where lessons learned from the increasing number of projects can be incorporated and provide guidance for efforts.

While additional guides will be developed to cover other renewable technologies, this guide covers onsite solar photovoltaic systems with an emphasis on third-party designed, financed, owned, and operated systems.

1 Introduction to the Solar Photovoltaic Specification Templates

It is well known that the project development process with solar photovoltaic (PV) system built on federal properties consumes a great deal of agency staff time with long development cycles, sometimes extending out years. Often, a development team expends a large fraction of the project development cycle composing a solicitation and contract documents. In addition to the time expended, agency managers often "reinvent the wheel" by composing new solicitation documents for each project, which can result in widely varying end results.

The enclosed template language and associated background information is intended to reduce the amount of effort required to prepare such documents, while improving the outcome of onsite renewable power systems—an attempt to save each agency from the effort of "reinventing the wheel." The enclosed template language is also intended to capture lessons learned from previous public and private sector projects, in order to create a more consistent federal practice, which in time can become familiar to bidders and the project finance community.

The enclosed specification language is intended for onsite projects that are financed, engineered, built, and operated by private-sector partners where agencies buy the energy produced. Some of the enclosed language should also be useful for utility energy services contracts (UESCs), energy savings performance contracts (ESPCs) or projects from appropriated funds.

This guide is mostly written using performance-based technical requirements, which is appropriate for third party owned systems. If the system will be government-owned then energy managers and contract officers should consider using more prescriptive language in some sections.

Benefits of Using Templates to Develop Technical Sections of a Solicitation

Using the templates can lead to a variety of benefits:

- Save time in compiling the specifications section of a solar procurement. The template language can be used as a starting point from which agency managers can customize their own language.
- Act as a checklist so that agencies managers address key issues throughout the process, to ensure the project's best possible outcome.
- As codes and standards lag field experience, provide interim language that can be used to increase the likelihood of a good outcome.
- Reduce confusion among offerors during the bidding phases of a project by providing clear and concise requirements.
- Promote common and good practices in federal sector renewables procurements that are recognized by the developer and project finance community.

How to Use this Guide

Template sections are divided by subject. Background information and rationales often precede the example template language when necessary. The background and rationale information is in a plain black font, and the template language is in an italic dark blue font. Template language that is self-evident is not preceded by background information.

Treat the enclosed template language like a menu, and choose language that applies to your project; not every example applies to every project. Agency managers are ultimately responsible for choosing language appropriate for a given project.

Codes and standards can lag behind by a few years; information coming from field experience can reveal important considerations that are not yet incorporated into a formal code or standard. The enclosed template language is considered to be a living document where regular updates will be made as new insights are gained. Please submit suggested updates using the enclosed comment form (Attachment 1).

Before you start, consider potential impacts on your facilities from privately owned on site renewable power systems. Don't assume anything and certainly never assume solar projects are risk free Agency managers taking on their first solar PV procurement may make some assumptions that could lead to problems later. Avoid problems altogether by considering the following common assumptions about third-party owned and operated onsite systems:

1. **"I'm just buying the power output, so if the system fails, it is the system owner/operator's loss."**
   a. These systems are located on the roof and property of agency sites and can adversely affect federal facilities. Consider property and safety issues.
   b. Space is limited! Most agencies have limited room at their sites, so roofs, parking lots, and ground areas made available for development can be a very valuable resource. In a scenario where a solar array fails prematurely or underperforms, that limited and potentially valuable space then becomes tied up until a resolution can be negotiated.
   c. PV systems are designed to last many years. An underperforming asset may be on a building for 20-30 years, taking up space that could have been used for a high-performing PV asset.
2. **"If a system fails, my agency will undertake a termination for default action and rebid the project allowing the new contractor to reuse any part of failed system"**
   a. System failures can happen with damage to the facilities, property and electrical systems they are located on and connected to.
   b. Agency procurement staff invests a large amount of time and effort ($) into a procurement of this complexity. Since it is so easy to avoid the most common risks, do it right the first time and avoid the losses.
3. **"There are module, inverter, and system output warranties, and the project is bonded, so all my liabilities are covered."**
   a. Companies in any industry do go into bankruptcy, and if all its assets are liquidated, warranties and bonding will most likely disappear as part of the process of closing out its assets and liabilities.
   b. Even in cases where the companies providing warranties are financially sound, having to call upon a warranty claim can be stressful and time consuming for agency managers and attorneys. Plan carefully and think ahead to avoid stressful claims.

c. Instead of just relying on warranties, agencies should also put in place a reasonable set of quality, performance, and safety specifications. Avoid the stress of a disagreement with a vendor and instead plan and execute a well-thought-through project that will meet your expectations.

d. Module warranties do not cover labor costs.

4. Important Implications: "Lowest Cost Technically Acceptable" and "Best Value"

a. One of the central decisions that agency energy and contract managers will make in selecting a contractor has to do with the trade-off between the lowest cost ($/kilowatt-hour [kWh]) systems and the higher-producing (annual kWh) but costlier systems, and the many ancillary benefits that might be incorporated into a proposal. Given the wide variety of solar PV equipment and design choices, there is a wide range of prices ($/kWh) and system annual kWh production. The "best value" selection methodology is ideally suited to facilitating this critical trade-off decision-making between price and performance.

b. Making this trade-off with "lowest cost technically acceptable" system is very challenging. It requires agency managers to be very prescriptive when stating a required performance level, which is very difficult to do and stymies important, innovative proposals that industry might submit.

The Uniform Contract Format (UCF)

The enclosed template language uses the Uniform Contract Format (UCF), which is commonly used in the federal sector (see https://acc.dau.mil/CommunityBrowser.aspx?id=38087). The UCF template can be easily adapted to other contract formats.

This guide covers four sections of the UCF that address technical factors. Section C typically contains the bulk of the technical specifications but Sections E, L and M also contain applicable material.

- Section C: Description/Specifications/Statement of Work
- Section E: Inspection and Acceptance
- Section L: Instructions, Conditions, and Notices to Contractors or Respondents
- Section M: Evaluation Factors for Award
    - Best Value
    - Lowest Cost Technically Acceptable

2 Section C: Description/Specifications/Statement of Work

Government Objectives

Though not legally enforceable, some language can be useful to convey to bidders the strategic and overarching goals agencies may have for a project.

Below are some examples of strategic goals you might include at the beginning of Section C.

Some of the benefits that the government wishes to realize from this project include, but are not limited to, the following:

- *Annual solar PV production to be at least "X"% of site annual consumption (kWh), as averaged over the previous three years*
- *Reduce the operating costs of federal buildings*
- *Create a degree of certainty to future energy costs*
- *Exceed federal and internal agency sustainability mandates and goals*
- *Promote the development of sustainable and renewable energy sources and related technologies*
- *Decrease reliance on greenhouse gas-producing energy-generating systems*
- *Provide leadership by example within the federal government*
- *Create locations for electric vehicle (EV) charging stations, integrated into shaded carports by making these structures "EV Charger Ready"*
- *Provide fleet vehicle shade protection from direct exposure to sunlight as part of solar PV systems installed in parking lots*
- *Make effective use of often limited and valuable ground, roof, and carport areas made available for solar arrays by the government. Effective use is maximizing annual kWh production and/or maximizing annual savings based on the current electric rates.*

Places of Performance

Providing some basic information up front allows the bidder to begin to assess your site(s) using satellite and solar PV modeling tools. Table 1 identifies pertinent information to include.

Table 1. Basic Site Information to Include in Section C

Introductory Site Information Basic Information to Include	
Site Name	e.g., "Roberts Federal Building"
Year Built	
Roof Age	
Building Use	Describe how the building is used: offices, residential, industrial, or mixed use.
Street Address	
City, State, and ZIP code	
Serving Utility	
Previous 12–36 Months of kWh Consumed	Use 3 years of data to estimate annual kWh use.
Annual Electric Expenditure ($)	Include costs for 1–3 years.
Peak kW during on, partial, and off periods	Use peak kW from the previous 12 months.
Areas Open for Solar Development	Roof, ground, parking lots, or other
Estimated Area Available	State in square feet or acres

Background

The following text provides much of the basic information that contractors need to understand what will be expected of them and the system.

The contractor shall generate safe and reliable renewable energy from solar photovoltaic (PV) systems sited on federal government property over the contract life. The electricity shall feed into government *electrical distribution systems on the "customer side" of utility meter. The contractor will design and construct, own and operate turnkey electric power generating systems built and operated on federal government property, at the locations listed in this document in accordance with all sections. The services included by the contractor shall include operation and maintenance of all components of solar PV systems for the life of the contract, as detailed herein.*

The systems shall convert solar radiation into AC electric power at a voltage compatible with the local utility grid power distribution system and acceptable to the local utility distribution company. At a minimum, each system shall consist of:

- *a solar photovoltaic generation system*
- *all necessary support structure and mounting provisions*
- *all necessary reinforcement of existing support structure*
- *terminal and combiner box(es)*
- *quick-connect solar panel electrical connectors*
- *cable and wiring*
- *conduits*
- *a DC disconnect*
- *a grid-connected inverter*
- *an AC disconnect*
- *all metering and control equipment*
- *a system monitoring and data retrieval sub-system*
- *ground and arc fault protection and alarming*
- *an electrical grounding sub system*
- *everything necessary to interconnect with site electrical distribution systems.*

In addition to the above, the contractor shall provide all incidentals required, such as the agency's electrical distribution system impact studies and needed modifications, permits, approvals, environmental and historic compliance, freight, financing, procurement, monitoring, inspection, billing, and incidentals as necessary to design, construct, operate, and maintain all the complete solar photovoltaic generation systems, described hereinafter.

If Your Site is Space-Constrained

If you have limited space, and/or would like to keep the solar array footprint as small as possible, it is important to emphasize this project objective. In addition to the sample language below, there are other important terms and conditions you will want to consider adding. These are covered in later sections of this document.

All agency sites (roof, ground, parking lot) shall be considered space constrained. Open areas made available by federal agencies are to be viewed as a scarce resource. Federal agencies seek solar arrays that are engineered and constructed with high-quality components (modules, inverters, transformers, *circuit protection, and conductors) and methods in order to maximize kWh production and dollar ($) savings per square foot. For sites with time-of-use (TOU) and/or demand rates, solar PV systems are to be designed to offset the greatest amount of electricity in higher cost-rate periods and achieve the greatest annual dollar savings.*

Existing Feasibility Studies and Engineering Studies Done by Others

Feasibility evaluations to determine the potential size of solar photovoltaic systems have not been completed. The contractor is responsible for ascertaining relevant site conditions to determine project feasibility and to determine final system size according to the terms of this solicitation. If any existing engineering studies or facility conditions reports are provided through this solicitation by way of the site information package, the bidder and contractor shall independently verify all information provided.

Discovery of Site Conditions "Differing Site Conditions Clause, Federal Acquisition Regulation 52.236-2"

The contractor shall conduct all work necessary to explore, inventory, and evaluate existing facilities (including, but not limited to: mechanical, electrical, utility, structural, and architectural conditions of facilities) in order to complete the project. Where this exploratory and inventory work requires opening of finish surfaces, uncovering, demolition, and/or excavation, the contractor shall promptly return all such areas to pre-construction condition or better upon completion of the investigations.

1. *Differing Site Conditions - FAR 52.236-2 apply.*
2. *As the project develops, it may evolve and change as new information is discovered. Minor changes in the Project should be expected, and the contractor shall make necessary adjustments accordingly. However, in the event of major or material changes, resulting in the need for a modification in services provided, then an appropriate contract modification(s) will be negotiated. Any changes in contract $/kWh costs, work scope, and time can only be authorized by the government Contracting Officer in advance.*

Codes, Standards, and Regulations

The Public Buildings Amendments of 1988, Public Law 100-678, section 21, requires that for new construction and renovation projects, the government shall, to the maximum extent feasible, be in compliance with one of the nationally recognized model building codes and with other applicable nationally recognized codes. The latest edition of the nationally recognized codes, including the current accumulative supplements in effect at the time of contract award, shall be used throughout the project's design and construction. The government requires compliance to the following codes on all projects:

- *International Code Council (ICC)*
- *International Mechanical Code (IMC)*

- *International Plumbing Code (IPC)*
- *International Building Code (IBC)*
- *International Fire Code (including but not limited to Section 605.11); requires access and clearance around roof areas and other requirements related to fire protection.*

Table 2 lists the applicable codes and standards organizations and their websites. Table 3 summarizes the codes that may be applicable to your Solar PV project.

Table 2. Codes, Standards, and Best Practices Organization Resources

Code and Standards Organization		URL
ACI	American Concrete Institute	https://www.concrete.org/
AISC	American Institute of Steel Construction	https://www.aisc.org/
ASCE	American Society of Civil Engineers	http://www.asce.org/
ASTM	American Society of Testing and Materials International	http://www.astm.org/
IEC	International Electrotechnical Commission	http://www.iec.ch/
IEEE	Institute of Electrical and Electronic Engineers, Inc.	https://www.ieee.org/
NFPA	National Fire Protection Association	http://www.nfpa.org/
NIST	National Institute of Standards and Technology	http://www.nist.gov/
NRCA	National Roofing Contractors Association	www.nrca.net/
NREL	National Renewable Energy Laboratory	http://www.nrel.gov
OSHA	Occupational Safety and Health Administration	https://www.osha.gov/
SEAC	Structural Engineers Association of California	http://www.seaoc.org/
UFC	Unified Facilities Criteria	http://www.wbdg.org/ccb/browse_cat.php?c=4&a=2
UFGS	Unified Facilities Guide Specifications	http://www.wbdg.org/ccb/browse_cat.php?c=3
UL	Underwriters Laboratory	http://ulstandards.ul.com/

Table 3. Summary of Code Topics and Descriptions

Topic	Code	Code Organization	Description
Safety	Multiple	OSHA	Occupational Safety and Health Administration Regulations for Construction; all regulations apply to all aspects of the project, with special attention to requirements for electrical safety and fall protection.
Safety	Title 29 Code of Federal Regulations	OSHA	1910 Occupational Safety and Health Standards
Safety	Title 29 Code of Federal Regulations Section 01546	OSHA	1926 Safety and Health Regulations for Construction. Government Safety and Health specification (Exhibit 6)
Steel Work	AISC Manual of Steel Construction (latest edition)	AISC	Best Practices - Applies to any steel work.
Concrete	ACI-318	ACI	Requirements for Structural Concrete (ACI-318, latest edition)
Civil Engineering	ASCE-7	ASCE	Minimum Design Loads for Buildings and Other Structures
Electronics and Engineering	IEEE C2 NESC	IEEE	IEEE C2 National Electric Safety Code (NESC) as applicable to modifications to the utility system not covered by National Electric Code (NEC)
Electronics and Engineering	IEEE P929	IEEE	P929 Recommended Practice for Utility Interface of Photovoltaic (PV) Systems
Interconnecting Distributed Power Systems	IEEE 1547	IEEE	Standard for Interconnecting Distributed Resources with Electric Power Systems
Interconnecting Distributed Power Systems	IEEE 1547a	IEEE	Describes means and methods for inverter low-voltage ride through, low-frequency ride through, and power factor adjustments. Must be used with mutual agreement of Contractor, the Government, and the Utility.
Interconnection of PV Systems	IEC 61727	IEEE	Photovoltaic (PV) systems – Characteristics of the utility interface
Inverters	IEEE 519	IEEE	Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
Inverters and Converters	IEC 62109	IEC	Safety of power converters for use in photovoltaic power systems, both Parts 1 and 2

Inverters, Converters, and Controls	UL 1741	UL	Inverters, Converters, Controllers, and Interconnect System Equipment for Use with Distributed Energy Resources
PV Module	IEEE 1262	IEEE	Recommended Practice for PV Module Qualification, Performance, and Reliability
PV Module	IEC 61215 & IEC 61646	IEC	Design qualification and type approval for crystalline silicon and thin-film PV modules

Table 3. Summary of Code Topics and Descriptions (cont'd)

Topic	Code	Code Organization	Description
PV Module	IEC 61730	IEC	Module safety qualification
PV Module - Safety	UL 1703	UL	Standard for Safety for Flat Plate Photovoltaic Modules and Panels
PV Module - Testing	ASTM - E1026-08	ASTM International	Standard Test Methods for Electrical Performance of Non-concentrator Terrestrial Photovoltaic Modules and Arrays
PV Module – Hail Test	ASTM - E1038-10	ASTM International	Standard Test Methods for Determining Resistance of Photovoltaic Modules to Hail
PV Module – Temperature and Humidity Testing	ASTM - E1171-09	ASTM International	Standard Methods for Photovoltaic Modules in Cyclic Temperature and Humidity Environments
PV Module – Grounding Testing	E1462-00(2006)	ASTM International	Standard Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules
PV Module – Visual Inspection	E1799-08	ASTM International	Standard Practice for Visual Inspection of Photovoltaic Modules
PV Module – Mechanical Integrity	E1830-09	ASTM International	Standard Test Methods for Mechanical Integrity of Photovoltaic Modules
PV Module – Test Method	E2848	ASTM International	Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance
PV Module – Reporting Performance	E2939	ASTM International	Standard Practice for Determining Reporting Conditions and Expected Capacity for Photovoltaic (PV) Non-Concentrator Systems
Control System – Security	800-82	NIST	Guide to Industrial Control Systems (ICS) Security Standard (Draft)
Solar Balance of System	IEC 62093	IEC	Balance-of-system components for photovoltaic systems - Design qualification natural environments
Racking Systems	UL 2703	UL	Rack Mounting Systems and Clamping Devices for Flat Plate Photovoltaic Modules

Performance Monitoring	IEC 61724	IEC	Photovoltaic systems performance monitoring – guidelines for measurement, data exchange and analysis
PV System Safety	IEEE 1374	IEEE	Guide for Terrestrial PV Power System Safety
PV System Safety	IEC 62548	IEC	Installation and Safety Requirements for Photovoltaic (PV) Generators
Safety – Military Sites	UFGS 01 35 26	UFGS	Governmental Safety Requirements
Smart Grid	IEEE 2030	IEEE	Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with Electric Power Systems and End-use Applications and Loads

Table 3. Summary of Code Topics and Descriptions (cont'd)

Topic	**Code**	**Code Organization**	**Description**
Commissioning, Documentation, Tests, and Inspection	IEC 62446	IEC	Grid connected photovoltaic systems – Minimum requirements for systems documentation, commissioning tests and inspection
UL – Listing		UL	Underwriters Laboratory (http://www.ul.com). Only products that are listed, tested, identified, or labeled by UL or another nationally recognized testing laboratory shall be used when available. Non-listed products are permitted only when listed products do not exist. Non-listed products must be identified as such in all submittals and must be approved by the Government prior to use in construction of the systems.
Grounding and Bonding	UL 467	UL	Safety Standard for Grounding and Bonding Equipment
Arc-Fault Current Interrupters	UL 1699	UL	UL 1699 Arc-Fault Current Interrupters
Fire Life Safety	NFPA 1 Fire Code	NFPA	The entirety of the code applies.

Fire Life Safety	NFPA 70, National Electrical Code (NEC)	NFPA & NEC	Refer to the version of the National Electric Code (NEC), which is adopted by the local jurisdiction having authority. The electrical requirements of the NEC have been adopted by the Government in lieu of the technical electrical requirements of the ICC Electrical Code. All sections are referenced, with particular emphasis on the following articles: 1. NEC Article 300: Wiring Methods and Materials 2. NEC Article 690: Solar Photovoltaic Systems 3. NEC Article 705: Interconnected Electrical Power Production Sources
Fire Life Safety	NFPA 101	NFPA	Egress requirements of the National Fire Protection Association (NFPA 101). The Life Safety Code shall apply in lieu of other code references.
Structural – Roof Arrays	PV 1-2012 (or most recent)	SEAOC	Structural Seismic Requirements for Rooftop Solar Photovoltaic Systems
Structural – Roof Arrays	PV 2-2012 (or most recent)	SEAOC	Wind Design for Low Profile Solar PV Arrays on Flat Roofs
Structural – Military Sites	UFC 3-110-03 Structural	UFC	For military sites only, the following Unified Facilities Criteria (www.wbdg.org) are referenced.
Roof Systems	guidelines	NRCA	NRCA “Guidelines for Roof Systems With Rooftop Photovoltaic Components”
Roof Systems	NRCA “Roofing Manual”	NRCA	NRCA Manual

Table 3. Summary of Code Topics and Descriptions (cont'd)

Topic	Code	Code Organization	Description
Roof Systems and Waterproofing	NRCA "Waterproofing Manual"	NRCA	NRCA Manual
Roof Systems – Military Sites	UFC 3-301-01	UFC	For military sites only, the following Unified Facilities Criteria (www.wbdg.org) are referenced.
Electromagnetic Interference (EMI)	Covered under IEEE 1547 and UL 1741, listed above. EN 61000-6-3 Electromagnetic Compatibility – Part 6-3 Emission standard for residential, commercial, and light industrial. EN stands for European Standard, but we can borrow some concepts.		
Sustainability – Military Sites	UFC 1-200-02	UFC	High Performance and Sustainable Buildings – Military Sites
Historic Issues	NFPA – 1966	NFPA	Historic preservation guidelines – applies to all sites
Historic Issues	NREL – Guide	NREL	Implementing Solar PV Projects on Historic Buildings and in Historic Districts http://www.nrel.gov/docs/fy11osti/51297.pdf
Note: Unless otherwise noted, the latest edition is applicable to all codes, standards, and guides.			

Interconnection to Site and/or Building Electrical Distribution Systems

The Contractor shall provide interconnection of the PV system with the electrical distribution system and take actions to ensure that the PV system is compatible with the electrical distribution system. The Contractor shall propose the electrical design, point of interconnection to the electrical distribution system, and the voltage and phase configuration, for approval by the government and other involved parties such as the electric utility and fire marshal. Modifications or upgrades to the electrical system required to interconnect the PV systems are the responsibility of the contractor. Contractor to propose needed upgrades or modifications under the review and approval process outlined in the submittal section herein. The Contractor is responsible for the proper circuit sizing, overcurrent protection, and coordination of the circuit(s) beyond the point of connection, including modifications to the federal site's electrical equipment and circuits; all at the Contractor's expense. Any modifications to the approved PV system design that would affect the electrical distribution system shall require written approval of the government.

Local Utility Interconnection Requirements

The Contractor is responsible for complying with all electric utility interconnection requirements, providing all necessary PV system details for the interconnection applications, and funding any required interconnection studies to be performed by or on behalf of the electric utility. The Contractor is *responsible for gaining approval from the electric utility for interconnection and any electric utility-required upgrades. The government will assist in facilitating communications with the Utility for this purpose. The electric utility interconnection agreements to connect the PV systems to the grid will be signed by the government or Contractor as required by utility agreements.*

The Contractor shall submit an electric utility interconnection process plan to the government within 14 days of contract award. The plan shall include key steps, timeline, interconnection details, and assumptions necessary to complete the interconnection process.

The contractor shall be subject to and shall satisfy the interconnection requirements of the electric utility serving each project site. The contractor shall provide any needed repair and upgrade to site electrical distribution equipment to meet interconnection requirements. The contractor shall provide to the local utility if required: single line diagrams, engineering power flow studies, estimated energy production data estimates, and other specifications and data with respect to the proposed new generating systems.

Any local codes required by utility interconnection laws and regulations shall be followed, and the contractor will be responsible for fees, permits, and inspections.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider the effects of their actions, including real estate activities such as leasing, design, and construction, on the human environment and alternatives that have the potential to reduce the impacts of those actions, and to prepare detailed statements for public and federal agency review where significant impacts may occur. The Council of Environmental Quality's implementing instructions can be found at 40 C.F.R. parts 1500–1508, and the government's implementing instructions can be found in the Public Building Service's NEPA Desk Guide - October 1999 (http://www.gsa.gov/graphics/pbs/PBS_NEPA_Deskguide.pdf).

The Contractor shall provide, at the Contractor's sole cost and expense, the following:

- ***Hazardous Materials/Due Diligence –** The Contractor shall indicate if any hazardous materials will be disturbed, encountered, or used in the construction of these solar modules. The Contractor shall provide all appropriate mitigation measures, if required, to reduce impacts to insignificant levels. See Section C.16 "Hazardous Substances Control."*
- ***Noise Pollution –** The Contractor shall provide a description of construction activities and mitigation to reduce noise related to construction.*
- ***Traffic Impacts –** The Contractor shall provide mitigation measures to reduce traffic impacts on local streets during construction, e.g., road/sidewalk closures, use of cranes, etc.*
- ***Jurisdictional Approvals –** The Contractor shall provide required development approvals from the county and/or municipality. It is understood that conformance to all applicable approvals are at the sole cost and expense of the Contractor.*
- ***Storm Water Runoff Management –** The Contractor shall provide sufficient documentation to demonstrate that the requirements of Energy Independence and Security Act (EISA) section 438 are being met. The Contractor shall not change the pattern of storm water amounts or runoff. If*

the project involves digging/trenching in soil of an area more than 50 linear feet, the Contractor must provide an erosion and sediment control plan.

- ***Viewshed Analyses –*** *The Contractor shall provide viewshed drawings depicting the potential visual impacts of the solar installation on each building.*
- ***State Historic Preservation Offices –*** *The Contractors shall comply with local, state, and federal State Historic Preservation Offices requirements (http://www.nps.gov/nr/shpolist.htm).*

Federal Communications Commission

Per Federal Communications Commission Part 15B, the PV system shall not emit electromagnetic interference (EMI) that interferes with other communications, and incoming EMI shall not cause problems with the control or performance of the PV system. If the PV system emits EMI, the Contractor shall turn off the system and take measures (e.g., cancellation, shielding, ferrite choke) to eliminate the emission of EMI prior to restarting the system.

Permits and Licensing

The contractor shall be responsible for preparing all permitting and licensing applications for the project. This includes, and is not limited to, providing all required supporting documentation, data, and information that the permitting and licensing agencies may require. The contractor shall coordinate all such work and be the primary liaison with the permitting and licensing agencies. The contractor shall be solely responsible for all permitting and licensing fees. The contractor shall comply with all requirements of permits and licenses issued for the project.

Local Fire Marshal Involvement

The Contractor shall involve the fire marshal or organization responsible for fire protection to provide design advice and design approval. The Contractor shall review the design of the system with the fire marshal and also observe design guidelines regarding firefighter access in the International Firefighter Association and the Government's November 2009 "Fire Safety Guideline for Photovoltaic System Installations" These guidelines include requirements for pathways through the array, cutouts where firefighters can pass each other and lay down equipment, and for smoke ventilation, required markings and signage, and other important information. The Contractor shall invite local firefighters to a training where firefighters will be shown how the system works and how to shut it down, and shall work with fire marshal to determine where to post the permanent instructions and required markings.

Contractor shall coordinate with local Fire Marshals on:

- *Signage*
- *Shutoffs*

- *Arrays on roofs - setbacks*
- *Training for first responders*
- *Posted instructions for shutoffs*
- *CAL Fire Ratings - Module Ratings*

Engineering and Construction

Professional Engineer and Licensed Design Professionals

All architectural and engineering (A-E) services shall be performed by design professionals licensed in the state in which the project is being built with responsible control for each respective design discipline. Upon request by the government, all design and/or coordination meetings shall be attended by the A-E licensed design professionals, at no additional cost to the government.

Registration Seals

Each submitted final design drawing, calculation document, and specification manual shall be signed and dated by, bear the seal of, and show the State Certificate Number of the Architect or Engineer who prepared the document and is responsible for its preparation.

North American Board of Certified Energy Practitioners Installers

The installation crew shall include at least one North American Board of Certified Energy Practitioners certified installer.

Coordination of Professional Services

The contractor shall be responsible for the professional quality, technical accuracy, and coordination of all investigations, evaluations, drawings, testing, cost estimating, submittals, written reports, construction, operations, and all deliverables, as required by this Scope of Work document or as required to complete the work of this contract.

Coordination of Subcontractors' Credentials

The contractor shall ultimately be responsible for the completeness, accuracy, and coordination of all submittals but may delegate the preparation of submittals in whole or in part to subcontractors or suppliers.

Modifications and Alterations of Government Property

Modifications, alterations, and/or additions to existing facilities shall be designed and certified to satisfy applicable requirements of this Statement of Work (SOW) document and the governing codes and standards referenced in this SOW document.

Structural Engineering

Structural Engineering For Low-Slope/Flat Roofs

For arrays on flat or low-slope roofs (<=7 degrees), current American Society of Civil Engineers ASCE 7.05 or ASCE 7.10 must be augmented by the use of Wind Loads on Low-Profile Solar Photovoltaic Systems on Flat Roofs, *Structural Engineers Association of California – SEAOC Report #PV2-2012, August 2012.*

Page 6 of the SEAOC report lists the following changes/additions to ASCE 7-10 with flat roof systems:

1. *Adding Section 29.9 to address solar arrays on flat roofs*
2. *Modifying Table 29.1-1 to include solar arrays*
3. *Adding Figure 29.9.1 to determine pressure coefficients for solar arrays*
4. *Adding a definition of Effective Wind Area for solar arrays*
5. *Adding Section 31.6 to address wind tunnel testing of solar*

Submit structural engineering calculations showing use of SEAOC Report #PV2-2012.

The Contractor must conduct a structural analysis and waterproofing study of each roof and design the PV system to ensure the structural integrity of the PV installation and that the structure of the building is not compromised. The structural analysis and waterproofing study shall include but not be limited to: the weight of the PV system itself, wind, snow, and seismic loads. Structural analysis shall include consideration of concentrated loads as equipment is staged prior to installation or during relocation of the PV system. The information in Section XX regarding the condition of the various facility roofs is provided as background information, but the Contractor is ultimately responsible for performing its own field investigations and determination of system design. The Contractor shall design the systems for minimal building penetrations. Number and design of penetrations is subject to approval by the Contracting Officer. Where roof penetrations cannot be avoided, they shall be properly sealed.

If the structural analysis shows that the roof requires major repair, either the Government will pay for the repairs, or the building can be eliminated from the project; at mutual agreement between the Government and the Contractor. The Contractor shall be responsible for minor roof repairs, for $10,000 per building or $50,000 in aggregate.

Structural analysis shall factor in water, snow, and ice ponding loads, as appropriate for the site's climatic conditions. If the roof has existing water ponding issues, the addition of arrays shall not substantially worsen ponding conditions.

Products, Material, and Service Requirements

Site Service Conditions

Materials shall be designed to withstand the year-round temperatures and conditions to which they are exposed (sunlight, heat, rain, cold, wind, seismic, salt air, fog, marine corrosiveness, etc.).

Same Manufacturer and Product Line

All modules, inverters, and electrical switchgear are to be of same manufacturer and product line for each array.

New Equipment

The Government shall not accept used, reconditioned, after-market, or grey-market products or equipment. Any offeror supplying used, reconditioned, after-market, or grey-market products as the result of any contract award issued as a result of this solicitation may be held responsible for damages to the Government.

Corrosion Resistance

All PV hardware and rack components shall be of corrosion-resistant material, such as stainless steel, aluminum, or hot-dipped galvanized steel.

Locating Equipment and Appearance

Major electrical components, including the inverter, isolation transformer, and metering, shall be installed in code-compliant enclosures. Components shall be located indoors whenever feasible, in ventilated (non-air conditioned) utility rooms and where space and codes allow. When inverters and major electrical components are located outdoors they shall be protected from direct exposure to weather (sun, rain, snow, and sleet). A simple open-sided shed roof structure is sufficient, as is a location under shaded carport arrays. Inverters shall not be located on roofs in direct sun.

The Contractor shall coordinate with the Contracting Officer's Technical Representative (COTR) and Electrical Engineer (EE) regarding locations and appearance of all equipment, including PV modules, conduit, inverters, disconnect switches, wireways, and control and monitoring equipment. The COTR and EE must approve all locations prior to installation.

Marking (Labeling) Best Practices

Strict conformance to system marking (or labeling) requirements of PV systems and their components are crucial for the safety of operators, service personnel, emergency responders, and others. General PV system labeling requirements, as per NEC 2014 690 Ch. VI, and specific requirements from Articles 690 and 705, shall be followed. Include all required and desired labeling language in the design drawings for agency review.

Electrical equipment and components used in PV systems shall have markings that identify the manufacturer, size, type, ratings, hazard warnings, and other specifications. Equipment markings should never be removed, and all equipment markings must be durable for the environment in which the equipment is installed. Markings must be visible or easily accessible during and after installation.

All markings, whether applied in the factory or the field, shall be designed to withstand the environment in which they are installed (e.g., "UV rated" for outdoor labels) and permanently affixed to the respective equipment in a manner appropriate for the environment and compatible with the substrate materials. Field-applied markings are required on many types of equipment and components, including (but not limited to) conductors, connectors, conduits, disconnecting means, and point-of-utility connections, as are special markings for bi-polar arrays, ungrounded arrays, battery storage systems, stand-alone inverters providing a single 120-volt supply, and other marking as required by local codes.

Expected Service Life

Unless noted otherwise, all materials furnished for the project shall have an expected service life of thirty years (30) or more, given the unique service conditions of each array site. Equipment warranties (modules, inverters, switchgear) are shorter than the expected service life. With a 30-year system life, it is common and well understood by industry that inverters and a small percentage of failed modules would need to be replaced though the system as a whole would provide at least 30 years of service. Agencies should seek the type of equipment and workmanship that can result in a 30-year system.

Minimum Transformer Efficiency Rating

Any new transformers installed, as part of Project shall be high-efficiency transformers. All such transformers shall comply with "NEMA Premium Standard" of The National Electrical Manufacturers Association (NEMA) and be of amorphous steel core with bio-based oil.

Module Efficiency Ratings (Updated July 2015)

Concern with module efficiency ratings should be raised if your site is spaced constrained, relative to the desired size of a PV system (kW). If greatest savings ($) is sought, a careful balance of module efficiency and cost should be examined. Module ratings should also be a concern if there is interest in limiting the array footprint; for example, if aesthetic, environmental, or historic concerns require the array size to be small to minimize impact.

Module efficiency can be stated in two ways: through a prescriptive approach or performance approach. They can be used separately or combined in the same solicitation as a means to reinforce the requirement for higher-output arrays.

Prescriptive Approach
Stating an explicit efficiency minimum, e.g., 15% (Standard Test Conditions - STC)

Performance Approach
Stating a minimum array size (kW) or annual kWh production number (see Section 2.14.20 on developing minimums). By developing minimum array sizes, you will eliminate lower efficiency modules indirectly without having to be prescriptive.

Solar PV System Requirements

PV Module Potential-Induced Degradation (PID) must be prevented or reversible through proper choice of inverter that are designed with PID prevention features.

Safety, Quality, and Reliability (Updated December 2015)

This section covers safety and reliability issues that are not yet considered to be covered adequately by current codes and standards. In addition, some sections below may add what is considered "prudent good practice" to existing codes. Agencies are encouraged to check back often for new updates to this document and with the codes cited in this section.

CODE NOTE: In anticipation of pending code revisions, and also to provide the available safety features, PV systems shall include automatic arc-fault detection, interrupt, and alarm (operational indicator). Expect future revisions of NEC and IEEE codes to cover the issue outlined below.

Array Arc and Ground Fault Detection and Prevention

Use Language as Interim Solution (August 2015)

Hardware shall be included to detect DC ground and arc faults. Once faults are detected, automatic system shutdown must occur, and the Contractor shall dispatch qualified electrical technicians to the site within 24 hours to locate the fault and make necessary repairs.

Acceptable Array Ground and Arc Fault Hardware Detection Schemes

For Grounded Systems

1. *An arc-fault detection system which is listed by OSHA's Nationally Recognized Testing Laboratory (NRTL) and compliant to the 2014 National Electrical Code must be installed. If a fault occurs, the system must shut down and send an automated alarm to the Contractor.*
2. *The PV system must include string-level DC residual current detector(s) (RCDs) that disconnect faulted circuit(s) and transmit an alarm alert to the Contractor.*

For Ungrounded Systems

1. *An arc-fault detection system, which is NRTL-listed and compliant to the 2014 National Electrical Code, must be installed. If a fault occurs, the system must shut down and send an automated alarm to the Contractor.*
2. *The PV system must include DC residual current detector(s) (RCDs) that disconnect faulted circuit(s) and send an automated to the Contractor.*
3. *The inverter includes a morning wake-up isolation resistance (Riso) check through built-in hardware. If the test fails, the system must shut down and send an automated alarm to the Contractor.*

Array Glare and Glint Prevention Analysis

The Contractor shall conduct a glint/glare analysis, as necessary for Federal Aviation Administration (FAA) review, using the Solar Glare Hazard Analysis Tool (SGHAT, https://share.sandia.gov/phlux) after the conceptual design is approved by the Government. The SGHAT analysis may need to be repeated if changes are made to the size, shape, or orientation of the PV system, as these changes could have an effect on glare. At a minimum, the information required for the analysis includes:

- *Location (depicted on map) and size of the array*
- *The roof height and the height of the panels above the roof*
- *Array orientation and panel tilt*
- *Module surface material*
- *An outline of the rooftop, as well as the usable areas of the rooftop upon which the PV array will be constructed*

If the SGHAT analysis shows that the PV system glare does not meet acceptable levels, the design shall be modified as much as practicable to minimize glare. If it is not possible to modify the PV system design to eliminate the glare hazard, the PV system will be dropped from the project list.

Recommended background reading regarding glare:

Kandt, A., and R. Romero. 2014. *Implementing Solar Technologies at Airports.* www.nrel.gov/docs/fy14osti/62349.pdf.

Ho, Clifford K. 2013. "Relieving a Glaring Problem." *Solar Today* 28–31. April. www.omagdigital.com/publication/?i=152579.

Cyber Security

All equipment to be installed at Government sites may be subject to cyber security screening to ensure that no security vulnerabilities are exposed or data breaches are created.

As a good starting reference for agencies, The SunSpec Alliance has published a thorough guide on this topic, which is available at http://sunspec.org/wp-content/uploads/2015/06/SunSpec-Best-Practice-Guide-Security-Recommendations-A42025-1.1.pdf

Lightning Protection

If a dedicated or separate grounding electrode is added for the lightning suppression, as is described in NEC 2014 Section 690.47(D), then the "Auxiliary Grounding Electrodes" must be bonded to the premises' grounding-electrode system.

Module Quality and Safety

Over the life of a contract, failures with most solar PV system components are easily addressed and represent only short-term loss of power output and some inconvenience; however, if modules fail and fail in large numbers, this is a serious issue for both contractor and host agency. Large numbers of module failures represent potential loss of savings, life-safety hazards, property damage, and time-consuming and embarrassing circumstances.

While module failures overall are relatively low, they do occur and preventing failures should be a high priority for agency managers. Module failures can be one of three types: (1) full failure with no power output, (2) severe degradation of power output, or (3) life-safety and/or property damage.

The solar PV market is growing quickly and experiencing intense pressure for cost reduction, with many new low-cost companies entering the market, company mergers, and bankruptcies. With intense competition between module manufacturers, the main components (solar cells, encapsulates, back sheets, and inter-cell conductors) and manufacturing processes are changing quickly, with unknown long-term durability and safety results. Do not rely solely on warranties or third-party insurance and bonding. Instead, also require every project to use qualified modules that are designed and manufactured to be durable enough to perform over the contract period and beyond. Requiring qualified modules should and can be common practice, and should not be seen as unnecessarily burdensome to bidders.

The primary existing design qualification standards International Electrotechnical Commission (IEC) 61215 (crystalline cells) and IEC 61646 (thin film) have been successful in preventing initial early life module failures but insufficient in predicting failure modes seen in the field over time.

As researchers and standards committees work to update standards, agency managers need to adapt interim language in solicitation and contract document requirements that ensure that qualified modules are used by the contractor and owner.

For very large utility scale projects (several MW in size), customers can request testing of a statistically meaningful group of modules from the same batch slated to be shipped to project site. Specialized third party consulting firms perform this service for industry stakeholders and do on the spot inspections of manufacturing facilities to verify quality programs.

Ensuring Qualified Modules Are Used

The National Renewable Energy Laboratory (NREL) has developed a module quality program called "Qualification Plus (QP)" (http://www.nrel.gov/docs/fy14osti/60950.pdf) that makes a series of recommendations that are either new or improvements to existing accelerated tests. The Qualification Plus recommendations are becoming integrated into updated standards. These recommendations are based on statistical correlation with predicting module reliability and durability over long periods of service life.

Figure 1 is an excerpt (Table 4) from the NREL Qualification Plus report summarizing the recommended updates. It summarizes the proposed changes at the time of publication.

Table 4. Summary of Standards Under Development or Not Usually Included in Type Testing

Standard or Proposal	Description	Status
Standards that are generally applicable		
IEC 62782 Dynamic Mechanical Load Testing for PV Modules EN 12211 Windows and doors. Resistance to wind load. Test method.	Apply ±1000 Pa at a rate of 1 to 10 cycles/min for 1000 cycles with current flow; quantify power loss	IEC is refining draft; EN is published
IEC 62804 Test Method for Detection of Potential Induced Degradation of Photovoltaic (PV) Modules	Apply system voltage in configuration such that leakage current may flow; quantify power loss	Refining draft
ASTM E2481-06 Hot Spot Protection Testing of Photovoltaic Modules	Longer stress: *e.g.* 50 h at 1 kW/m^2 [35] Selection of susceptible cells and worst case shadowing	ASTM is published; IEC is planning a 5-hour test for Ed. 3 of IEC 61215
IEC 62852 Connectors for DC-Application in Photovoltaic Systems – Safety Requirements and Tests EN 50521 Connectors for Photovoltaic Systems – Safety Requirements and Tests	Set of tests for electrical, thermal, and mechanical performance	IEC is refining draft; EN is published
IEC 62790 Junction Boxes for Photovoltaic Modules – Safety Requirements and Tests EN 50548 Junction Boxes for Photovoltaic Modules	Set of tests for electrical, thermal, and mechanical performance	IEC is refining draft; EN is published
IEC 61730-2 Revision for 2nd Edition – Addition of MST 94 Weathering Resistance Test	Weathering test	Under development based on ISO 4892-2:2013 and ASTM D7869
IEC 62759 Transportation Testing of PV Modules – Part 1: Transportation and Shipping of PV Module Stacks	Mechanical test	IEC is refining draft
Weighted Junction Box Test [36]	Tests robustness of junction box mounting	IEC is refining draft for inclusion in Ed. 3 of IEC 61215
IEC 61788-x Polymeric Component Standards	Determine material parameters for prescreening	Concept stage
Bypass Diodes Electrostatic Susceptibility	Determine the susceptibility of bypass diode failure from an electrostatic event in the factory or field	IEC initiated a new work item in August 2013
Standards that apply to specific applications		
IEC 61701 Salt Mist Corrosion Testing of PV Modules	Tests durability for marine environments	Ed. 2 published
IEC 62716 Ammonia Corrosion Testing of PV Modules	Tests durability for farm or other conditions with ammonia	IEC 62716 is published
Non-uniform Snow Load Testing for PV Modules	Tests durability for bearing a snow load for a tilted module	IEC is refining draft; ANSI is developing TUV-R 71730

Figure 1. Table 4 from *Photovoltaic Module Qualification Plus Testing* (http://www.nrel.gov/docs/fy14osti/60950.pdf)

Applying Qualification Plus

Making the QP recommendations a requirement during the bidding phases is far too prescriptive and difficult for contractors to source module manufacturers that comply with the full list of proposed updates; as these tests are in the early process of becoming integrated into standards and adapted as standard practice in industry.

However, these updated tests could be used effectively by developing technical selection criteria for Section M. The selection criteria would then be used by the selection committee members to weigh carefully the modules proposed by each bidder. Since it will be difficult to find a module manufacturer that complies with the full list of updated tests shown in Figure 1, committee members can weigh those brands that have adapted at least some of the updates. For example, higher scores could be given to module models that have gone through the greatest number of the new updated tests.

Further information on module quality issues and proposed efforts can be found at:

Photovoltaic Module Qualification Plus Testing (http://www.nrel.gov/docs/fy14osti/60950.pdf)

Accelerated Lifetime Testing of Photovoltaic Modules
http://www.solarabcs.org/about/publications/reports/acceleratedtesting/pdfs/SolarABCs-33-2013.pdf

Upcoming standards can be monitored at the International PV Quality Assurance Task Force (PVQAT) website:

http://www.nrel.gov/pv/performance_reliability/pvmrw_20150225_wed_pvqat.html

Preventing Vandalism and Theft

If there is any concern that a solar system could be subjected to theft or vandalism, requirements need to be added to the solicitation and final contract. Make sure to ask bidders for suggested features that will address these concerns.

Here are example features that can be added to system requirements:

1. An appropriate fencing system with locked gates
2. Lighting
3. Security cameras
4. Security patrols
5. Motion-activated alarms and lighting
6. Tamper-proof fasteners on arrays and cabinet fasteners
7. Inverters, combiners, and main electrical switches locked with high-security padlocks
8. Anti-theft devices for copper cabling

Electric Metering and Data Acquisition Systems: Measurement and Verification (M&V)

It is important for agencies to realize that solar PV systems operate silently with no moving parts, which means that meters and sensors are needed to understand how well a system is performing and/or what electrical faults might be occurring.

Contractors will install electric meters to measure the output of DC and AC power produced by each system. For generating regular electric billings (for power purchase agreements), owners will place a meter(s) somewhere on the AC side, downstream from the inverter(s). Also installed will be a data acquisition system (DAS) and a weather station located alongside the array. The DAS collects and logs data from the weather station. These weather stations, at a minimum, often provide wind speed, array temperature, and solar radiation information.

How do system owners use meter data?

System owners use the electrical and site/array weather data to:

1. Generate regular (monthly, quarterly, etc.) electric bills for the solar power produced per the terms in the contract.
2. Establish the ability to monitor remotely the solar system output relative to weather, to determine if the system's performance meets expectations.
3. Monitor for power disturbances, electrical faults, and system outages. Some owners set up a system of alarms to detect and quickly react to urgent issues.
4. Dispatch service personnel when poor performance or system faults are detected.
5. Provide an online customer portal that provides access to some portion of the data, depending upon the functionality of the metering and communications hardware and what is negotiated in the final contract.

How might agencies use system data?

Over the life of the contract, agency managers might come across different needs for data. These may include the following:

1. Confirm accuracy of electric bills issued for the solar PV electricity generated.
2. Check and make sure solar system performance is within a reasonable range from what is expected in the contract in terms of such metrics as "Weather-Corrected Performance Ratios" kWh production and system uptime.
3. Quantify how much savings has been achieved and determine if the utility-provided net metering statement is accurate.
4. Determine the remaining load and power usage of the building or site after the solar PV has been installed.
5. Identify whether any adverse power disturbances have originated from the solar PV system or from some other sources, such as the utility grid or other equipment. For example, was the franchise utility's power distribution system adversely affected?
6. Receive automatic notice of any serious faults requiring immediate attention.
7. Use data for mandated score card reporting.

A note about energy security, micro-grids, and data needs: If you are building a solar array that will be associated and controlled as part of a micro-grid, you will be engaged in much more involved metering uses. Micro-grids and energy security are not covered in this template document.

Agencies that might want their own meter installed: Make sure at a minimum to add language to the bid and contract documents that give you permission to install a meter should the need arise during life of the contract. Agencies may want to require that a meter be installed alongside the owner's meter used for billing. The relatively small (typically $5,000) cost of adding an additional meter should not be a cost concern. During the life of the contract, if issues continue to arise over the quality of the metering data produced by the owner's hardware, you may want to install your own meter to use for bill verification and/or power management. Agency meter specification should include the means of communication (e.g., local area network, dedicated line, wireless).

If you are installing a small system or a series of small systems on one site, installing meters might be cost prohibitive. In these cases, make provisions with contractor allow you access to any digital or analog output signal that can be used to feed data to your building management system or power meter server.

Metering Specifications

Use a revenue-grade meter that meets the American National Standards Institute (ANSI) Standard C12.1-2008.

Data Polling and Logging Frequency

Metering Communications Pathways "Telemetry" Choices

There are several wired, wireless, or hybrid communications hardware options that can be used to establish a connection with array meters and data collection hardware and the World Wide Web. Agencies are urged to coordinate with site information technology staff to choose a method of communication that allows for a secure means for meter data to be collected.

Contractors will/will not have access to agency local area networks. Contractors will/will not need to following the following communications security standards (………)

Electric Metering for All System Types

Metering Requirements: Each PV system shall have an agency-specified meter installed in parallel to the contractor's meter used for billing purposes. The Contractor will purchase and install meter with the manufacturer's prescribed current transducers (CTs) and in a separate and appropriately NEMA-rated cabinet (if needed).

Meter and Site Data Acquisition System – Communications Options

1. Hardwired through CAT6e cabling to the nearest network closet
2. Wireless network connection to the site's network
3. Wireless communication connected to the owner's network
4. A cellular network
5. A hybrid approach

Sample Language

The electric energy delivery of the PV systems shall be measured by utility-grade metering equipment to be furnished, installed, maintained, repaired, calibrated, read, and reported by the Contractor at its expense. When more than a single meter is installed at a service location, the readings thereof may be billed conjunctively, if appropriate. The meter shall be located on the output side of the inverter (measured in AC) and support interval metering for real energy delivery, registering entries every 15 minutes. Identification and location of equipment being monitored must correspond with the submitted and approved drawings. If the inverter is configured to source reactive power, the metering system shall meter power factor as well as real power, although external monitoring of power factor or power quality may not be allowed at all sites.

For any connection to the Government's intranet and/or internet networks, the Contractor shall ascertain and comply with all cyber security requirements prior to operation. For those Agencies that allow the use of wireless technology and allow connection to a's intranet and/or internet networks, the SunSpec Alliance Standard Information Models (Exhibit 7), combined with standard transport protocols such as Modbus, Ethernet, Wi-Fi, and ZigBee (radio) are recommended, with support information models as defined in IEC 61850 and/or Smart Energy Profile 2.0. However no communication can be installed that violates NIST SP 800-82 protocols.

For those Agencies that do not allow the use of wireless technology, and therefore a site network is not available, the Contractor may use, at the tenant agency's sole discretion, a hard line communication or a phone line, a cellular connection, or other means that is 100% independent from the Government network. Any external communication connections must be located at the demarcation point to the public access or general work areas and must not interfere with other Government-used radio frequency networks. The recommended installation plans must be forwarded for approval to the cognizant security authority prior to installation. Any required connections shall be made by the Contractor at its expense.

The meter shall be a solid-state advanced meter with the following features: non-volatile memory capable of storing measured data for 30 days, using an Ethernet port, and accuracy meeting ANSI 12.20 0.5% accuracy. If connected, the electrical metering shall be compatible with the software currently used by each facility. However, due to security considerations and different IT management in each building, the Contractor should assume that access to the agency's network services will not be available, and that it may have to employ other communications means to collect data from metering systems. No meter shall be placed in service or allowed to remain in service that does not meet the accuracy standards of ANSI C12.20. Meters shall be tested for accuracy and certified in accordance with ANSI C12.20 at the Contractor's expense. The Government may test the accuracy of the meter at any time at the Government's expense, and if the accuracy is found to be greater than the 0.5% tolerance standard, the meter shall be replaced or repaired at the Contractor's expense.

The Contractor's meter data shall be available to the Government in both a Microsoft Excel file format and on a password-protected Contractor-managed website. All monitoring hardware and monitoring equipment shall be provided by the Contractor. Guidelines regarding data availability are as follows:

- The data shall be available both in real time and archived in fifteen (15)-minute intervals for the current billed month, as well as for the previous billed month.
- System performance shall allow display during different monitoring periods from one hour to one year (hourly for a day, daily for a month, monthly for a year), along with an estimate of what the system should have produced, as calculated by the performance model during that time interval using the appropriate local weather file. The performance model provides an estimate of how much electric energy the PV system on each building should have delivered under weather conditions over the month. The performance model should use System Advisor Model (SAM) or other software approved by the government. If the measured performance (AC energy delivery) differs from the prediction of the performance model by more than 30% for a month, 20% for two consecutive months, or 10% for three consecutive months, the Contractor shall identify and rectify the cause of the discrepancy, including making repairs to components of the PV system and calibration of the meter and monitoring equipment. Applicable standards include ASTM E2848 (Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance), ASTM E2939 (Standard Practice for Determining Reporting Conditions and Expected Capacity for Photovoltaic [PV] Non-Concentrator Systems), and IEC 61724 (Photovoltaic System Performance Monitoring—Guidelines for Measurement, Data Exchange and Analysis).
- Archived information shall consist of monthly summaries of system performance from the date of inception. Archived data shall be available upon request to observe long-term trends in system performance. Collected data shall be archived on an ongoing basis for the duration of the contract.
- At the end of the contract period of performance, this data archive shall be delivered to the Government on machine-readable media accessible by the Government.

Setting System Size Minimum and Maximums and Performance Guarantees

To ensure that your agency realizes its project objectives, it is critical to set minimum and maximum system sizes (in kilowatts and/or annual kilowatt-hour numbers) in both the bidding documents and the final contract. Minimums are important during the bid phases to avoid “cream skimming” (where only the most attractive locations are considered and included in the bid responses) and then during the life of contract period to help enforce performance guarantees. Minimums stated in bid documents versus those established and agreed to in the final contract (part of performance guarantees) should not be confused with one another—they are used for separate purposes.

Maximums are designed to ensure that systems are not installed that produce more electricity than your annual usage— “net excess generation” because in most states they do not benefit utility customers. Most sites are space constrained and use far more electricity (kWh) on an annual basis than can be produced by an onsite solar PV system, making the use of a maximum irrelevant.

Of course, there are many states and regions that have complicated requirements and or incentives such as feed-in-tariffs and payments for net excess generation. In these cases, a more detailed model will need to be used in order to determine the optical array size.

Minimum System Sizes in the Solicitation – Avoiding "Cream Skimming"

First, system minimum sizes (kW or annual kWh) need to be stated in bid documents to make sure all qualified areas made available by agencies for array development are included in the bid submissions. This is a means to avoid "cream skimming" by bidders. Minimum system sizes should also produce more uniform responses from bidders, which eases the bid evaluation process.

To further enforce system minimum sizes in bid responses, add minimums to the a technical evaluation factor in Section M, to rank bid submissions based on how effectively the viable spaces made available are utilized for solar arrays.

How to Set Minimum System Sizes

Agency managers can use a few simple rules of thumb, along with the online tool "PV Watts," to derive a system size. A rough estimate should be accurate enough to set a minimum value in the solicitation documents.

Follow these simple steps to derive a minimum system size (kW) and annual production (kWh):

1. Measure the surface areas to be used for solar arrays.
    a. Roof areas: Subtract from the measurements areas around HVAC, vents and telecommunications equipment, parapets, penthouses, heavy shaded areas, shaded areas with large amounts of leafy debris or sap, roofs with less than 10 years of age remaining.
    b. With sloped roofs, in many states there must be a three-foot (3′) border between the array and the lower edge of the roof, peaks, valleys, and hips.
    c. For parking lots, include only the surface area above the parking stalls, which are usually 160–180 square feet (sq. ft.) in size.
    d. With ground systems, exclude areas that would be needed to site inverters and other electrical equipment. Subtracting 5% of total usable area for electrical equipment is sufficient.
2. Multiply the available surface area (sq. ft.) using the following power density numbers to get an array size.
    a. Thin-film modules: 6 watts/ sq. ft.
    b. Standard-Efficiency Silicone Modules: 8 watts/ sq. ft.t
    c. High-Efficiency Silicone Modules: 10 watts/ sq. ft.
3. Convert total watts to kilowatts: Divide by 1,000.
4. Use the PV Watts® Calculator, Version 2: http://pvwatts.nrel.gov/.

a. Make sure to use the simple information buttons next to each input line. This will ensure the correct values are entered.

5. Use the final annual kWh generated by the PV Watts V2 tool as your system minimums.

Performance Guarantees – Minimum System Sizes in Contract Documents

In contracts, the life of the contract performance of the arrays can be expressed as a "Weather-Adjusted Performance Ratio," and/or in monthly, quarterly, annual kWh output. Though the final system size and annual output may not be completely set until the final contract negotiations, agencies must state the method that they will use to determine system performance over the life of the contract in advance and make sure both bidders and contractors agree to the methodology and datasets used to make the evaluation.

Two Ways to Ensure Minimum System Sizes (kW) in the Solicitation

First, agencies can add bid evaluation/selection criteria that grades a bid proposal based on how well all qualified areas open for arrays are utilized. Qualified areas are those locations that are thought to be free of obvious and serious NEPA, structural, and electrical issues. Using this method of adding a bid evaluation factor is the easier of the two options; less prescriptive, it gives bidders the greatest latitude to innovate and avoids having to undertake the process of estimating what a reasonable system size would be.

The second method is to estimate, through measuring areas and applying a few conservative assumptions, what a minimum size (kW) should be. After measuring all areas and applying reasonable assumptions, minimum kW sizes can be added to the solicitation. Both can be used together in the solicitation at the same time, which is important when you hope to get the greatest possible system size (kW) from space-constrained sites.

Sample Language

The Government estimates the total PV system to be X kW, and will only accept a proposal that is no less than 10% smaller than the estimates.

After the contract award, the Contractor can recommend PV system sizes at their discretion, as long as the total aggregated PV system size is within plus/minus 10% of the original estimate. Certain buildings can be added or subtracted, subject to Governmental approval. The power price ($/kWh) shall be guaranteed as long as the total aggregated PV system size is within plus/minus 15% of the original estimate.

Setting Performance Guarantees: Establishing Weather-Corrected Performance Ratios and System Minimum Production Values (kWh) for the Life of the Contract

The International Electrotechnical Commission (IEC) is currently working to update the IEC 61724 standard to incorporate the use of the Weather-Corrected Performance Ratio. The following is drawn from Dierauf, Timothy and Growitz, Aaron, *Weather-Corrected Performance Ratio,* National Renewable Energy Laboratory, April 2013.

Using Weather-Corrected Performance Ratios (WCPR) provides a simple, yet powerful means for agency managers to establish a performance metric, which can then be used upon initial system startup (acceptance testing) and during the life of a contract to ensure that guaranteed system performance is met.

As long as certain conventions are followed, the WCPR is considered fair to all stakeholders; investors, developers, operators, and hosts.

The WCPR is a ratio of the total AC output of the solar system divided by the nameplate rating (Standard Test Conditions, STC) of all modules in an array, corrected for weather. Values will be less than 1.00.

While the process involved and the actual formula used to calculate the WCPR is much more complex, in its most basic form, the WCPR can be pictured as:

$$\frac{\text{AC Output of Solar Array (Modeled and Measured)}}{\text{Total Number of Modules x STC Rating of Module x Weather-Correction Factors}}$$

Performance Variables Considered in the WCPR
What makes the WCPR so powerful is that it accounts for the major factors that influence system performance losses. Important loss factors accounted for in the WCPR include the following:

a. Inverter efficiency
b. Array tilt and azimuth (orientation to south)
c. DC and AC wiring losses
d. Weather, elevated cell temperature
e. Module solar cell mismatch
f. Module age
g. Downtime
h. Shading
i. Component failures

Using the WCPR During the Life of a Contract
To use the WCPR performance metric, it will have to be agreed to and established in the contract. The value agreed to in the contract will be the result of system modeling (projected), while the value used during the contract performance period (system tests) will be the result of measured field data (actual).

To make a comparison between what was projected in the contract and the actual values derived from field measurement, the following protocols must be agreed to in the contract:

1. An agreed-to WCPR value must be stated in the contract, along with a test plan to include provisions for any anomalies that might occur.

2. Field measurements and data collected should be done by the contractor, but by way of an independent commissioning agent.
3. All data and spreadsheets must be made available for review by agency managers and representatives.
4. Add language to bid documents and the final contract that the Weather-Corrected Test Protocol that starts on page 8 of NREL's *Weather-Corrected Performance Ratio* should be agreed to and followed. Once the new IEC test protocol is released, that can be substituted for the guide.
5. The corrected performance ratio in the final contract should be within 95% of the performance ratio calculated during the test.

Weather-Corrected Performance Ratio is available at: http://www.nrel.gov/docs/fy13osti/57991.pdf.

Net Zero and Setting System Maximum Sizes – Important Considerations
Interest in achieving "net zero" at agency sites has become a popular and a laudable project objective. *Net zero* should be defined as a percentage range, (e.g., 90% to 95%) of historical annual kilowatt-hour usage, but never 100% due to the variability of annual solar PV output combined with facility/site consumption (kWh) unpredictability. It is impossible to size a solar PV system to produce exactly 100% of site energy consumption (kWh). Exact annual solar production (kWh) and site usage (kWh) cannot be predicted in advance to a great level of accuracy.

If an agency site has the space, and system sizes are permitted by state law and regulations, then achieving net zero can be a realistic project objective; however, there are many complicating factors that need to be considered.

Measurement and Verification (M&V) Requirements during life of contract
With an ESPC, agencies have a statutory requirement to insert M&V language that mandates reporting by contractor throughout life of contract.

The selected Contractor shall substantiate the Contractor's ability to achieve cost savings every year of the contract term.

The Contractor shall utilize M&V Option B (see http://energy.gov/eere/femp/downloads/mv-guidelines-measurement-and-verification-performance-based-contracts-version) to meet the statutory ESPC M&V requirement, performing continuous M&V of energy system cost savings (kWh production times the unit ESPC ESA energy price). After system commissioning, the Contractor shall prepare a post-installation M&V report documenting measured kWh production over a 10 day period prior to acceptance. The M&V report shall document PV system performance measurement by measuring solar irradiance and temperature.

At least annually, the Contractor shall submit a report documenting the total kWh production, as measured by electric meter at output side of inverter or input side of the transformer, and confirming annual guaranteed savings compared to purchase from the serving electric utility.

The annual M&V report shall document any shortfall in annual guaranteed kWh production (taking into consideration expected PV module degradation), provide explanations for performance failure and action steps to restore production to estimated levels.

Setting a Net Zero Annual kWh Number

Figure 2 outlines some considerations and actions that must be taken to determine a net zero annual kilowatt-hour number.

Consideration	Action
Previous 3-Year Average kWh Usage	Average 36 months of usage
Planned for Conservation Projects	Include energy audit and report estimates of KWh reductions
Changes in Building Occupancy	Use a simple kWh/person estimation to add or subtract kWh
Demolition or Addition of Buildings	Use meter data or a reasonable kWh/sq. ft. metric
Changes to Onsite Food Service Operations	Use common kWh/sq. ft. metrics for kitchens (http://www.fishnick.com/)
Large Energy Using Equipment or Additions or Deletions	Ask a consulting engineer to estimate the energy usage involved with the equipment
Fleet Vehicle Chargers	Use 1 kWh per 3 miles of range to estimate miles driven by fleet vehicles
Commuter Vehicle Charging	Use 1kWh per 3 miles of range. Estimate commuter miles from surveys.
Net Annual kWh Usage	Sum together all numbers
Final Target System Size	Take a percentage of Net Annual KWh Usage – e.g. 90%

Figure 2. Some Considerations That Could Affect Annual kWh

Array Applications

Arrays on Flat and/or Low-Sloped Roofs

There are several reasons why self-ballasted roof arrays are desirable; however, there are often building conditions which can limit the use of ballasting. Self-ballasted systems obviously keep penetrations through roofing systems to a minimum, which in turn reduces potential leak points and maintenance costs. Also very important with ballasted systems is minimizing anchoring through roofing and insulation materials to the building frame. Connecting to a building frame can cause serious thermal bridging, which in turn reduces the building's performance.

Due to structural limitations, the full amount of ballasting may need to be reduced for a given facility. There are strategies and hardware that can be used to reduce the need for ballasting, such as use of cabling strung through an array that is anchored at the perimeter. Some vendors offer interlocking systems that make arrays strong as a whole, which reduces the need for ballasting and roof penetrations.

Fully Self-Ballasted Where Possible

Solar PV arrays on flat roofs shall be the self-ballasted style designed to minimize penetrations through the roofing system if roof framing is found by the structural engineer to be structurally capable of carrying loads.

Hybrid Approach

If the building structure cannot support the full amount of an array ballast, the Contractor shall propose a partially ballasted system that uses minimum roof penetrations. If the building structure cannot support any array ballast, and where high wind speeds warrant, fully anchored systems will be allowed as a last choice. For roofs where hybrid solutions can be accommodated (partially ballasted/anchored), array systems may in these cases incorporate a tie-down system that penetrates roofing in order to attach to underlying roof frame members. One such example is comprised of cabling strung through arrays with perimeter tie-downs to the building, but proposers are to recommend what they judge to be effective. Extra system tie-down will be allowed only where ballast weight needs to be reduced and/or wind speeds are high. A tie-down system that incorporates a minimum number of roof penetrations is preferred.

Fully Anchored When Necessary

When an anchored system is proven to be the only viable option, this type of system shall be allowed.

Annual Roof Inspection and Repairs

All roof-mounted array systems shall allow normal routine annual roof inspections and maintenance to continue unimpeded, and shall allow for visual inspections and physical access to the underlying roof system to perform needed roof inspections and repairs.

Weatherproofing Roof Penetrations

All roof penetrations shall be designed and constructed in collaboration with the roofing professional or manufacturer responsible for the roof and roofing material warranty. The number and size of the penetrations necessary to extend the power and control cable into the building must be kept to a minimum and grouped in a single location when practicable. All weatherproofing of penetrations shall be compatible with the roof warranty. Describe materials and methods to be undertaken to create watertight seals in the roofing systems for anchor points and conduit.

Rooftop Rigging Systems

In the instance there is a rigging system in place, the arrays shall not interfere with the normal function of building rigging and powered platforms.

Walkways and Access

Steps or ramps or other "bridging" shall be provided where defined walkways created for maintenance personnel to navigate in and around arrays for equipment access intersect with conduit, pipe, or duct runs.

Roof Warranties

Prior to the installation of the PV systems, the Contractor shall determine if a manufacturer and/or installer's warranty cover the existing roof system. If it is determined that the existing *roof system is under a manufacturer's warranty, the contractor shall engage the manufacturer representative and any other companies involved with service contracts or warranties regarding the PV system design; applied stresses; materials compatibility; installation details and methods; and repairs to any damage to the roof during installation. Roofing companies often require an "overburden waiver" to ensure that the solar system will be removed if warranty repairs are required. This will ensure a watertight and structurally sound installation and ensure that the PV system does not void the manufacturer's warranty. The Contractor shall provide manufacturer's shop drawings indicating the approved methods of installation in order to ensure the warranty remains in effect. The manufacturer's representative shall be allowed to provide oversight during the installation to ensure work is performed in accordance with approved methods. The Contractor shall provide documentation to the Contracting Officer of the roofing manufacturer's recommendation, with resolutions obtained for the continuation of the roof warranties. It is preferable for the original roofing manufacturer and warranty holder(s) to provide this oversight; however, if not feasible, then other roofing companies of similar qualifications and familiarity with the specific roof type and products may be engaged instead, with Government approval.*

Roof Replacements and Major Repairs During the Life of the Contract

Given that contracts terms range from 20 to 25 years, it is likely that either major repair or replacement will occur, requiring part or all of an array to be moved aside temporarily and then placed back into position.

Adding re-roofing provisions in the original contract has three advantages:

1. They provide a means to competitively set costs in advance. So that agencies are not exposed to price gouging if and when a roof repair/replacement event occurs.
2. They include provisions for any re-roofing or major repairs that would require the contractor to temporarily move part or all of an array as a component of the competitive bidding process.
3. They identify in advance who the responsible agent will be when moving arrays for roofing work.

Sample Language: Option 1 – Roof Replacement

The Contractor will assume that one roof replacement will occur during the life of the contract. The Government will pay costs to temporarily remove the arrays and balance-of-system components that interfere with roof replacement. Once the roof replacement work is completed, the Contractor will restore the system to normal operation according to the output warranty schedule.

As part of the bid response, the Contractor will provide the total cost of temporarily removing and restoring solar PV systems. The price provided by the Contractor in the bid response shall be for Year One (1).

For the year in which the roof replacement occurs, the Year One (1) bid price shall be inflated (compounded) using Consumer Price Index (CPI) numbers to determine the current cost of the temporary removal and restoration.

The determination of the amount of energy that would have been produced during the relocation shall be based, during the first Contract Year, on the estimated levels of production and, after the first Contract Year, based on actual operation of the system in the same period in the previous Contract Year, unless Seller and Purchaser mutually agree to an alternative methodology. "Contract Year" means the 12-month period beginning at 12:00 AM on the Commercial Operation Date or on any anniversary of the Commercial Operation Date and ending at 11:59 PM on the day immediately preceding the next anniversary of the Commercial Operation Date, provided that the first Contract Year shall begin on the Commercial Operation Date.

The Contractor will have thirty (30) days from the written or verbal notice to restore the system to normal operation. If the Contractor fails to restore the system within the thirty (30)-day period, the Contractor shall not receive payment for lost electricity sales. If the system is not restored within one (1) month of roof replacement completion, the government shall retain the services of a qualified solar PV firm, at Contractor expense.

The Contractor may be provided a staging area to store components onsite only if the room is available, as determined in coordination with government site managers.

Sample Language: Option 2 – Using Only Part of the Roof Area

If you have limited roof space and want to maximize system size, this may not be a good option for your site. Finding an area onsite to store modules while the roofing project is taking place could also be a severe problem, and so you may have to consider the approach contemplated below, regardless of the desire to maximize system size; forcing a contractor to store modules offsite would most likely be prohibitively expensive.

The default is that the solar projects will cover two-thirds of the available roof space, to allow for a phased roof replacement if necessary during the contract term. The cost for a one-time relocation of each of the PV systems is required, in case roof replacements are necessary. The cost should assume that the relocation would occur in Year Five (5) and shall include removal, storage, reinstallation, and three (3) months of lost revenues. Proposals can include solar projects that cover more than two-thirds of the roof if: this does not negatively impact the roof replacement and roof relocation plan, it will reduce the power purchase agreement (PPA) price, and it does not significantly increase the one-time relocation cost. If the offeror proposes to install PV systems that will occupy more than two-thirds of the roof, the proposal shall include sufficient information for the Government to determine its acceptability.

Sloped Roof Arrays

In regions prone to sliding snow and ice, consider using a heavy snow-rated modules and snow/ice guards in specific areas where building occupants are at risk of snow/ice shedding. Examples of sensitive areas for hazards of sliding snow and ice include roofs over building entries, driveways, and walkways.

Shaded Carport Arrays

Choosing Shaded Carport Type – Waterproof Rain Structure or Simpler Shade Structure

There are two main types of solar shaded carport structures with respect to weatherproof elements: water/weatherproof and non-weatherproof.

For the water/weatherproof shading option, the arrays are mounted on top of a fully weatherproofed roofing system. Having a waterproof roof as part of the shaded structure is not only a nice added convenience, but an absolute necessity in any region that experiences more than just occasional freezing weather.

The non-weatherproof shading option is a structure that is not watertight and allows rain to drip through between modules. Each option carries important implications that need to be considered carefully:

Option 1: Watertight Structure Implications
Costs for this type of watertight structure will be higher, due to the addition of roofing systems, gutters, downspouts, and the larger structural framing needed to support the added wind and weight loading. Depending on site conditions, there could be added costs to divert the rain captured by gutters to a site drainage system. In a worst-case scenario, a NEPA study might require the addition of a new site feature to manage storm water runoff coming from the shaded structures.

These structures provide a greater level of convenience by allowing users to enter and exit vehicles under a sheltered structure, and they also prevent snowmelt from dripping through and creating areas of ice and a fall hazard. Also, falling snow and ice that can shed from the structure must be considered. Make sure the design accounts for managing snow and ice slides, to prevent harm to individuals and property.

Gutters and downspouts may need to be kept clear of leafy debris. If so, this would add maintenance costs.

Broader site water management issues may arise, as the water that is shedding from the shade structure gutters will need to be managed according to applicable codes. This kind of structure could present a good opportunity for the installation of a rainwater capture system, providing for a water conservation opportunity. Rain barrels could also provide a source of emergency water supplies.

Option 2: Shade-Only Implications
Precipitation will fall through the gaps between modules and provide no protection from rain, sleet, and snow. In cold climates, melting snow dripping through between the modules may refreeze on the parking lot surfaces below, presenting a serious fall hazard. However, in relatively dry and hot regions, this option could be perfectly acceptable, and provide highly valued and beneficial shade.

Shaded Structures and Vehicle Clearance
Solar-shaded carport structures present excellent opportunities to protect all kinds of government equipment (e.g., boats, tractors, plows, large trucks, supplies) and/or fleet vehicles. Vehicles and equipment exposed to the elements have a shortened service life and higher maintenance costs.

1. For passenger cars and vans, ensure at least nine (9′) of clearance at the lowest edge.

2. For larger vehicles and equipment, agency representatives should take careful measurements to set minimum height requirements based on height of vehicles and equipment to be stored under the structures.

Architectural or More Utilitarian Structure

Consider relaxing the requirement to build architectural-grade structures in equipment yards that are out of view. This would be especially important for structures that are taller, made to accommodate large government vehicles.

Other Critical Considerations

Existing underground utilities running through or even nearby the parking lot are important for the contractor to locate in advance.

Template Language

The Contractor shall furnish and install a complete photovoltaic carport structure, with the photovoltaic array complete and operational in grid-connected operation.

The shade structure shall have a roof deck that will support the PV array and shall control the fall of water and ice onto vehicles and occupants.

The shade structure shall **include / not include** *architectural measures (roof deck, gutters, downspouts) to prevent water from falling under or around the shade structure and forming areas of ice that can lead to slip-and-fall hazards. Offerors shall include a description along with a drawing set explaining how ground ice will be prevented.*

The shade structure shall **include / not include** *architectural measures to control ice, water, and snowfall.*

General Design Guidelines

For double-wide rows, carports shall be designed to be supported by central support posts and cantilever over parking spaces on both sides, like a "T." For a row at the edge of the parking lot, carports shall be designed to be supported by a braced post and cantilever over the parking space, like a "7."

All carports are intended to be of similar design, at an approximate width that will cover two cars parked end to end, and of varying lengths. The width may range between 36 feet and 40 feet, and lengths may be adjusted by plus or minus four feet to match and optimize various panel layouts. Federal agencies seek a balance between aesthetics and maximizing electrical production.

The PV panels on the carport shall be sloped to balance aesthetics and power production. The carport PV shall be at least 9 feet clear in all locations.

All light-gauge, cold-formed structural members and panels shall be designed in accordance with the latest version, with addendums, of the American Iron and Steel Institute (AISI) "Specification for the Design of Cold-Formed Steel Structural Members."

Welding of the light-gauge, cold-formed structural members shall be in accordance with the latest version of the "Structural Welding Code - Sheet Steel" (AISC/AWS Dl.3). All structural steel sections shall be designed in accordance with the latest version, with addendums, of the AISC "Specifications for the Design, Fabrication and Erection of the Structural Steel for Buildings."

The steel roof panel shall be coated steel conforming to ASTM A792, ASTM A653, or ASTM A611, with a minimum yield strength of 80 kilopounds per square inch (ksi) or equal. The roof panels shall be factory pre-painted.

Light-gauge steel beams and columns shall conform to ASTM A653, with a minimum yield strength of 55 ksi.

Concrete shall be done in accordance with the latest edition of ACI 318 "Specifications for Structural Concrete for Buildings," and shall be 2,500 pounds per square inch (psi) at 28 days. Reinforcing shall be new billet steel conforming to ASTM A615, grade 40.

All steel framing fabrication shall be done by an approved fabricator and certified by an independent agency, for the type of fabrication required. Certification shall be as required by the local municipality.

Welders holding a valid certification for the type of welding required shall perform all steel welding. Certification shall be as required by the local jurisdiction.

The submittal shall include: Carport Drawings (stamped by an Engineer licensed in DC); Carport Structural Calculations (stamped by an Engineer licensed in DC); Standard Colors; and renderings as required for the compliance process approval.

Contractor is responsible for locating all existing underground utilities prior to excavation and for utilizing the "Call Before You Dig – http://call811.com" hotline to confirm with any potentially affected public utility company locations of underground utilities. Any damage done to existing underground utility systems are the sole responsibility of the Contractor.

If site utility drawings are provided by Government, they are for informational purposes only, and are to be considered incomplete and inaccurate; Contractor is responsible to confirm the exact location and type of underground utilities.

Underground utilities that may be found traversing a parking lot might include but are not limited to: telecommunications trunks, cable TV lines, electrical distribution conductors, water mains, oil and natural gas lines, access and security camera systems, waste water and/or storm water drain pipes, traffic and/or street light power, and communications cabling.

Parking Lot Lighting

Existing parking lot lighting poles and fixtures illuminating the proposed solar PV carport areas shall be removed, and lighting shall be restored by new light-emitting diode (LED) fixtures mounted to the carport structure. The LED fixtures shall be FEMP-designated (100 lumens per watt or greater) and/or ENERGY STAR-rated and controlled through photocell and motion sensors if dimmed during off hours. The lighting layout shall achieve minimum Illuminating

Engineering Society of North America (IESNA)-recommended foot-candle levels and uniformity for parking lots (ANSI/ASHRAE/IESNA Standard 90.1-2007) and also comply with the most recent version of the International Dark-Sky Association (IDA)/IESNA lighting ordinance (Model Lighting Ordinance).

Lighting for Shaded Parking Structures

New, array-mounted light fixtures shall also provide illumination levels and distribution needed to support existing security camera systems. The proposed lighting layout and specification shall be part of the submittal package. The Contractor shall coordinate with government security officials to select a final lighting layout.

Fire Lanes

Fire lanes established to access any adjacent facility by local fire department shall be maintained and comply with state, county, and local Fire guidance. Changes to fire lanes are allowed, but only under approval by Fire authorities having jurisdiction over the site and under coordination and approval by the agency project manager. Fire lanes are to be shown on submittal drawings.

Delivery Zones

The Contractor shall work with site facility engineers to designate truck routes through the site to ensure that the shaded carport structures are compatible with deliveries.

Snow Loads and Module Choices

In regions prone to sliding snow and ice, use heavy snow-rated panel and snow guards.

American with Disabilities Act (ADA) Compliance

All changes to the parking lot shall comply with ADA requirements.

"EV Charger Ready" for Shaded Carport Systems

The installation of solar PV-shaded carport systems involves a great deal of underground trenching as a means to route array wiring and as a way to interconnect electrically with the main building service panel. The routing of array and system wiring is very close to that required to install electric vehicle chargers. Trenching to install underground conduit/wiring for EV chargers represents a large cost and inconvenience if not done along with the solar arrays. When agencies install solar PV-shaded carport systems, it is recommended that contractors be asked to install spare conduit in the open trenches as a means to enable the installation of electric vehicle chargers at a later date.

Designate stalls so that offerors know how many "EV Ready" parking spaces there will be, and where they will be located.

For agencies interested in making a solar-shaded carport "EV Ready," to prepare for a time when it will be legally possible to charge at a federal facility, consider choosing from the language below.

Other than inverter selection and spare communications conduit, for the purposes of this RFP, no other hardware or engineering shall be included. Any charger shall be established by the agency by a future procurement separate from this RFP.

Agencies seek to make these designated parking spaces "EV Charger Ready" so that future installations of chargers (installation of actual EV chargers to be done in the future under a separate effort) do not have to retrench the parking lot. EV charger conduit will largely follow the same trench pathways used for the PV power cabling to the main service panel. To achieve an "EV Charger Ready" design, spare conduit for power and communications are to be added to trenches opened for the Solar PV project.

EV Charger Ready is the concept of leveraging the open trenching used to route the solar PV power cabling to include EV charger electrical conduit. The trenching pathways needed to interconnect the solar PV carport arrays to a main electric service panel are largely the same as those needed to run EV charger wiring. Agencies seek to install spare conduit with pull string in open trenches to enable the future installation of EV chargers to be funded at a later date under a separate procurement.

Installation of chargers is not within the scope of this project; however, the contractor shall utilize open trenches to install spare electrical conduit to enable the future installation of EV chargers. Spare conduit is within the scope of this project.

For the purposes of this RFP, the contractor shall assume parking stalls to be served by double-service, Level 2 EV (208/240V) chargers, with each charger requiring one (1) forty (40)-amp circuit served by a forty (40)-amp two-pole breaker. The Contractor shall install one (1), one-inch electrical conduit for every two circuits. The Contractor shall stub out conduit according to details in the scope of work (SOW) section.

Authority to Establish EV Charging Onsite for both Federal Fleet and Employees Vehicles

Agencies are now authorized and directed to establish EV charging stations for both fleet and personal use. The installation of solar shaded carports is an excellent opportunity to at the very least install the underground infrastructure needed. This allows agencies to come back at a convenient time and install the chargers needed.

Fixing America's Surface Transportation Act (FAST Act), Pub. Law 114-94, H.R. Section 1413:

In December of 2015, the FAST Act authorized agencies to install, operate and maintain electric vehicle (EV) and plug-in electric vehicle (PIEV) charging equipment for employee use. The authority requires federal agencies to charge employees who use the charging station a fee to ensure that the federal agency recovers all of the costs in installing, constructing, operating, and maintaining the station.

Brownfield's Site Development – EPA "Re-Powering America's Land"

For agencies interested in exploring the use of impacted lands as locations for solar arrays, the EPA in collaboration with NREL has developed a program called "Re-Powering America's Land" This program has an associated website with a large amount if information for owners of brownfield sites interested in renewable energy. https://www.epa.gov/re-powering

Ground-Mounted Arrays

All ground-mounted electrical supporting equipment (inverters, transformers, and switchgear) shall be installed on concrete slab(s) with appropriately sized and spaced rebar. The sizes and strength of the pad and rebar shall be adequately calculated and designed by the contractor.

The Contractor shall provide and maintain site protection to keep children, vandals, deer, and other wildlife, and unauthorized personnel out of the ground sites. At a minimum, provide chain link fence a minimum of six (6) feet high with a lockable gate. The key is to be provided to Government. The Contractor shall provide for vegetation growth control in the PV parcel and shall be responsible for a fire control and weed control program. The Contractor shall procure a construction activity storm water permit and then install a storm water runoff collection system at down gradient of the PV field to collect and safely channel collected rainwater to natural runoff channels to minimize erosion.

The Agency shall approve the fencing, gravel, fire control program, weed control program, and storm water runoff collection system.

Contractor is responsible for locating all existing underground utilities prior to excavation and for utilizing the "Call Before You Dig – http://call811.com" hotline to confirm with any potentially affected public utility company. Any damage done to existing underground utility systems are the sole responsibility of the Contractor.

Any site utility drawings provided by Government are for informational purposes only and are to be considered incomplete and inaccurate. Contractor is responsible for confirming the exact location and type of underground utilities present.

Underground utilities that may be found traversing proposed array areas might include but are not limited to: telecommunications trunks, cable TV lines, electrical distribution conductors, water mains, oil and natural gas lines, access and security camera systems, waste water and/or storm water drain pipes, traffic and/or street light power, and communications cabling.

Micro-Grid Ready, Power Factor, and Utility Grid Support Requirements

The intent of the following model "Micro-grid Ready" RFP language is to enable agencies to plan ahead if there is a desire to establish a micro-grid with the solar PV system in the future. Even though the funding needed to establish a micro-grid may not be available at the time the solar PV system installation is contracted, several simple considerations can be added that will allow the solar system to be part of a micro-grid. This model language can be used as is, or modified, based upon the PV project goals.

This model language is intended to enable the solar project to provide ancillary services (with or without a micro-grid) that can be important to the serving utility, and to reduce power factor charges. The document includes RFP language to include if the solar project is implemented through a third-party financing method such as a PPA or energy savings performance contract (ESPC).

General Requirements: Requirements to include with all PV projects. Other standard requirements (such as NEC) could be added, so it is a comprehensive list.

Sourcing Volt-amperes Reactives (VARs): Requirements to include if power factor correction using the inverter is desired, either because the site already has a poor power factor or because the PV system is expected to negatively impact the site power factor.

Micro-grid Ready/Other Grid Support: Requirements to include either because the PV project should be micro-grid ready or because there is other grid support that would be beneficial to the site and/or utility.

General Requirements (not all inclusive)

The PV system shall comply with the National Electrical Code (NEC), Underwriters Laboratories (UL) 1741 "Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources," IEEE 1547[1] "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems," IEEE 1547.1 "IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems," and all other interconnection requirements specified by [serving utility]. The inverters shall be certified by an OSHA Nationally Recognized Testing Laboratory (NRTL) to comply with UL 1741 tests for inverters. If there is a system disturbance (voltage and frequency outside the parameters of IEEE 1547) under normal grid-connected circumstances, the inverters shall turn off and cease to produce power.

Sourcing or Sinking VARs

For sites with non-unity power factors, the addition of PV can further degrade the power factor (as seen by the utility). If the resulting power factor penalty charges justify the added investment cost, the inverters shall have the capability to adjust the site power factor to [x] by sourcing or sinking reactive power. Adjustments shall be either programmed locally (autonomous control) or be implemented upon receipt of a variable power factor command provided by the remote power system controller. The inverters shall have a range of dynamic reactive capability that supports its operation from a [y] leading to [z] lagging power factor. The intent is to control power factor and to provide electrical distribution system support to the utility if requested. A non-unity power factor for the inverter shall be allowed. The inverter shall be capable of sourcing VARs even when the PV system is not operating.

The Contractor shall be compensated for lost real power (kWh) in exchange for sourcing VARs.

Micro-grid Ready/Other Grid Support

The inverter shall be capable of curtailing its output in logical steps in response to communication from the system controller. (One option is to have the capability to shed individual strings in addition to full curtailment.)

The inverter shall have adjustable trip limit and time-delay capability as defined by UL 1741, and advanced power control functionality—including reactive power capability (source VARs), power increase ramp rate control (and power decrease rate control if storage is available), and curtailment set points.

In some instances, the power system controller set points may be set outside of the UL 1741 and IEEE 1547 (including 1547a) requirements—with mutual agreement between the federal agency, the utility, the Contractor [and others such as fire marshal]—to allow for adjustment of the cease-to-energize limits and time delays specified in UL 1741 / IEEE 1547, including adjustments to the low-voltage ride through (LVRT), low-frequency ride through (LFRT), high-voltage ride through, and high-frequency ride through specifications.

The inverter shall be able to change settings via remote communications and be capable of real-time monitoring, diagnostics, and management in the grid-interactive mode and micro-grid (intentional island) mode via a remote power system controller and appropriate power analytics software.

Micro-grid Ready Only

In addition to connecting and operating in a grid-interactive mode, the Contractor's proposed PV system shall be capable of being included in a future micro-grid that can operate when the utility grid is unavailable. This micro-grid could include conventional (engine) generators, other renewable resources, and/or energy storage. For the purposes of this RFP, this requirement shall be met by the following:

PV inverters shall be multi-mode DC-to-AC inverters capable of switching between grid-interactive mode and micro-grid (intentional island) mode. The inverters shall comply with the IEEE 1547.4 "Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power System" standard. While in the grid-interactive mode, the inverters shall be capable of four-quadrant operation (real and reactive power in and out of the inverter).

If there is no isochronous generator in the system that sets frequency and voltage to the micro-grid, an inverter with battery storage needs to be selected to do this. Other inverters in the system will synch to this master inverter.

The Contractor shall install spare communications conduit in the trenches that could be used to route future communications cabling to a point of common coupling from the inverter(s). The communications conduit shall be capable of connecting the inverter with a remote power system controller and any other pertinent equipment. The duct bank shall include spacers to separate communications from power conduits. The Contractor shall coordinate with the site staff to ensure that the installed equipment meets micro-grid ready needs, within the budget established by the Contractor in its proposal.

The Contractor shall also consider space-planning issues such as pad space for batteries, as needed.

The Contractor shall cooperate with the site when requested to determine the necessary equipment and other changes required to meet future micro-grid requirements. The Contractor's proposal shall include [x] hours for this micro-grid coordination work. If additional effort is required, the Contractor will be compensated separately. Micro-grid configuration changes will be funded by the government. The Contractor's proposal shall also include details regarding how the proposed equipment meets the above requirements, how the equipment differs from a PV system that would only operate in the grid-interactive mode, and any other important considerations.

The third-party owner will be compensated for all power generated during micro-grid operation, using the same pricing schedule as other generation.

System Startup and Commissioning

The contractor shall provide all work required for testing, start-up, and commissioning as required by the following requirements.

Commissioning standard IEC 62446 shall be followed, and associated reports shall be included with the as-built submittal package.

The Contractor shall provide the services of the third-party Testing Agency that employs North American Board of Certified Energy Practitioners (NABCEP) or International Test Association (NETA) certified engineers or technicians to perform start-up and acceptance testing of the specified PV system.

An agency manger or representative may request to be present during any or all phases of the start-up and testing activities.

Complete a system commissioning per the Specification and equipment manufacturer's written instructions.

Request and coordinate with Utility and the Government representatives for acceptance and certification of the PV system and permission to operate.

Set and adjust circuit protection devices according to the Short Circuit and Coordination Study.

Commissioning shall include the Contractor's data acquisition system (DAS).

Maintenance and Operations During the Life of the Contract

The Contractor shall be responsible for all aspects of maintaining and operating the PV array(s), including but not limited to: cleaning the array(s), replacing broken or worn out system components, performing maintenance in accordance with equipment manufacturer recommendations, and the minimum performance standards established through this procurement. The Contractor shall maintain the solar PV array area, including mowing, raking, sweeping, mopping, dusting, snow removal, disposal of accumulated waste materials and rubbish, and other operations necessary to present a neat appearance. The Contractor shall *store all maintenance supplies and equipment only at an approved storage area so as to preclude theft or damage and maintain the site in a neat and orderly manner.*

Notice of System Damage and Management of Emergency Events

The Contractor shall promptly notify the Government if it becomes aware of any damage to or loss of the use of the solar PV systems or of circumstances that could reasonably be expected to adversely affect the arrays. The Contractor shall promptly notify the Government if it becomes aware of any event or circumstance that poses an imminent risk to human health, the environment, the solar array, or the Premises. The Contractor shall immediately dispatch the appropriate personnel to perform the necessary repairs or corrective action in an expeditious and safe manner. Notice will be provided to the Government personnel and the Contractor will be provided with contact information for the Government personnel at the time of award.

In the event the Contractor fails to respond as required in the contract, and in the event of emergencies, the Government may incur expenses to perform emergency repairs to Contractor-installed equipment, as well as Government equipment for which the Contractor assumed maintenance and repair responsibilities. The Contractor shall hold the agency harmless in such cases where the Contractor fails to respond appropriately in emergencies. The Contractor shall promptly reimburse the Government for any and all costs incurred in responding to such emergencies. Such reimbursement may include the Government adjusting the payment schedule, as necessary, to recover such costs.

Routine Main Electrical Service and Repair

On three separate occurrences per year, the building electrical distribution system may be shut off so that electrical preventative maintenance and repair can be performed on the building electrical distribution system. Each shutdown will not last longer than 24 hours, and government will make attempts to schedule the work during off-peak unoccupied hours; however, Contractor is to plan for daytime interruption of solar system output during these times.

Submittal and Review Processes

It is recommended that a submittal, submittal review, and approval process be established and stated in the solicitation and then be included in the final contract. Submittals and the review process is the opportunity to make sure the offeror (and subsequently, the Contractor) are following the requirements of both the bid and final contract documents. Responsiveness to submittal requests can be used during the selection process and through construction.

Also, as-built submittals over the life of the contract will become very important reference documents for such reasons as future renovations, emergency response, and long-term maintenance of any solar array the government owns.

The Government will review the design submittal and provide written comments within 10 days. The Contractor shall then prepare a 100% Design Development Submission. Agency technical representatives and COTR will review this submittal and provide written comments within 10 days.

The Contractor shall work with the Government Contracting Officers and each building's Contracting Officer's Representative for design review and approval for each submittal document required.

Provide drawings for each discipline required (electrical, roofing, structural, geotechnical, etc.), with separate plans for new work and demolition, as well as special types of drawings where necessary, such as enlarged plans, equipment curbing and flashing details, ground mounting and roof penetration details, etc. Detailed drawings shall be provided showing base and structural supports planned for supporting the array, i.e., footers, pylons, supports, etc. Drawings shall clearly distinguish between new and existing work. Each drawing shall indicate project title, project number, building name, building address, A/E firm, A/E's address and/or phone number, contract number, drawing title, drawing type, drawing number, and key plan. A cover sheet shall be provided and shall include a list of the drawings, legend, vicinity map, and location map in addition to all items required for each drawing. Each A/E submission shall be clearly dated and labeled (e.g., 75% Design Development Submission, 100% Check Set Submission, Construction Phase Shop Drawings, As-Built Drawings). Each drawing sheet submitted shall include a graphic scale in the lower right portion of the sheet. The final set shall be stamped by a registered engineer and/or registered architect for the jurisdiction in which the building is located.

Submittals can be categorized as follows:

1. Bid Response Materials
2. 75% Design and Engineering Phase
3. 95% Design and Engineering Phase
4. 100% Final Design
5. As-Built Documents, Acceptance and Operations Manuals

Choosing Design Review Cycles for Submittals

For smaller systems (< 1 megawatt) and/or for simple systems not involving any complicated technical issues, it is not uncommon for offeror and contractor engineers to quickly develop a 75% design set of drawings and product cut sheets. In these cases, a simpler submittal review cycle is warranted, rather than what is often seen in more complicated construction projects: 75%, 95%,100%, and as-builts—a four-step process.

For larger systems, and/or those that involve complicated technical and logistical issues, a submittal process involving more steps may be warranted such as the 50%, 75%, 95%, 100%, and as-builts—a five-step process.

As-Built Drawing Government Review Process

Should the Government determine that variations exist between finished construction and the As-Built Drawings, the Contractor shall correct the drawings to the satisfaction of the Government and the Agency.

As-Built Final Submission After the Review Process

The contractor shall submit six (6) hard copies and two (2) CDs containing the "as-built" drawings and specifications as CAD and PDF files. The As-Built drawings in CAD shall comply with the government National CAD Deliverables Policy. Including start-up, operation and maintenance manuals with spare parts lists, control diagrams, schematic and interconnection wiring diagrams of all electrical work, including terminal blocks and identification numbers, wire numbers, and wire colors.

All low-voltage wiring; communications, metering, and meteorological instruments; and fault detection/alarming systems shall have separate diagrams/drawings.

String labeling on drawings must match combiner box labels physically applied in the field.

Submit construction drawings for each PV system. Provide drawings for each discipline required (e.g., architectural, structural, electrical), with separate plans for new work and demolition, as well as special types of drawings where necessary, such as enlarged plans, equipment curbing and flashing details, roof penetration details, etc. Drawings shall clearly distinguish between new and existing work.

Each drawing shall indicate project title, project number, building name, building number, building address, Firm's name, Firm's address and phone number, contract number, drawing title, drawing type, drawing number, and key plan. A cover sheet shall be provided and shall include a list of the drawings, legend, vicinity map, and location map in addition to all items required for each drawing. Each submission shall be clearly dated and labeled. Each drawing sheet submitted shall include a graphic scale in the lower right-hand portion of the sheet. The final set shall be stamped by a registered engineer and/or registered architect for the state in which the building is located.

Note that the aesthetic character of the mounting structure and overall system installation will be considered. Thus, the proposal should include enough information to assess the solution's aesthetic characteristics. Inclusion of photographs, material samples, and architectural elevations are allowed under this item. Please include the height of the proposed system. The shaded carport systems must comply with the American with Disabilities Act (ADA).

Submittals: Document Review and Approval Process

Examples of submittal items may include the following:

Bid Response

- Initial Project Schedule
- Schematic System Layout (Ground, Roof, and Parking)
- Demarcation Point of Interconnection
- For Ground and Parking Systems, A Site Plan Showing Existing Utilities (water, gas, sewer, hydrants, storm drain, telecom), with a Solar Trenching Plan
- Proposed Equipment Cutsheets

- Calculations Showing System Sizes and Annual Kilowatt-hour Production
- Initial Demolition Plan
- Proposed Staging and Lay-down Areas, and Phasing Requirements for Shaded Parking Structures

75% Submittals for Review by Government

- Draft Electrical Single Line Drawing Set (shows interconnections, electrical cabling route, and communications lines)
- Demolition Plans
- Site Work Plans (hard and softscapes, and includes soil compaction specifications)
- Roof Waterproofing Details for any penetrations
- Roof Plans showing pathways established to allow maintenance personnel to access rooftop equipment. Walkways shall depict navigation pathways in and around solar arrays to existing roof equipment.
- Power Capacity (DC kW), as calculated at the inverter(s) input STC, rating
- Power Capacity (AC kW), as calculated at the electrical interconnection point wire loss, inverter loss, and transformer loss (if there are transformers, etc.)
- Annual Expected Minimum Output AC kWh Production, with a description of the estimation methodology used. Describe the calculation used. This must be consistent with values provided in the Price Proposal.

95% Submittals for Review by Government

- Copies of Permits and Licenses
- First Draft of Structural Drawings Showing SEAC Required Calculations
- Site Fencing and/or Vandalism and Theft Prevention Plan
- Existing Security Camera Modification Plan
- Lighting Layout and Fixture Cutsheets
- Layout Drawings of the PV system that include dimensions, access details, weights, the arrangement of the PV arrays, inverter, wiring, disconnecting means, metering devices, and point of coupling with the grid
- Electrical Plans, including single-line electrical diagrams showing utility interconnection and all devices comprising the PV system, including, but not limited to: PV arrays, combiner boxes, circuit breakers, disconnect switches, inverters, meters, timers, control devices, and other equipment comprising the complete system. Electrical ratings of all equipment and devices shall be clearly indicated on these single-line diagrams. Include sizing calculations.

100% Final Drawings Requirements

- *The Contractor shall utilize a designated commissioning authority to review and comment on the design prior to construction. The Contractor may not proceed with construction until designs have received final approval and the Government has issued a formal construction Notice to Proceed.*
- *The Contractor shall maintain a set of drawings for each of the PV systems, with all (Government-approved) design changes made during construction. Upon completion of construction, the Contractor shall submit final design documents, including, at a minimum, drawings that are updated to reflect all changes, with details of PV system structural support, any roof penetrations, electrical single-line diagrams, and complete product literature for review by the Government. A structural professional engineer shall sign and stamp the structural drawings, and a professional electrical engineer shall sign and stamp the electrical drawings. Five hard copies shall be submitted, as well as a CD with electronic copies of all documents.*

100% Submittals for Review by the Government

- Stamped Drawing Sets
- Final Cutsheet (modules, inverters, disconnects, meters and overcurrent protection equipment, arc fault sensing, and disconnect systems)
- Manufacturer's Drawings

As-Built Documents

- Shop Drawings Used During the Project
- Major Components – User Manuals
- One Training Session for Site Facilities Engineers
- As-Built Structural Drawings
- As-Built Electrical Drawings
- As-Built Site Drawings
- Spare Parts List
- Site Reference Materials for Emergency Operations – Building Operators
- Final Commissioning Report
- The Local Utility Company's Letter of Certification accepting the PV system and grid tie-in and granting permission to feed electrical power into the local utility electric power grid.

Warranties

- **Total Array Output Warranty.** If the performance (as reported in submittal Schedule XXX) falls below specifications during the Contractor's or Subcontractor's warranty period, the Contractor or Subcontractor at the Contractor's or Subcontractor's expense shall replace or repair the defective equipment. The measurement made under actual installation and temperature will be normalized to standard test conditions using the temperature coefficients published in the module specifications.

3 Section E: Inspection and Acceptance

Inspection

The Contractor shall conform to the requirements of FAR Clause 52.246-4, Inspection of Services – Fixed-Price, which is included by reference in this solicitation and Contract.

The Government Contracting Officer or the delegated Contracting Officer's Representative may inspect the PV systems at any time during construction or after the PV systems have been put into operation. The Contractor may be ordered to stop work, or shut the systems down, if unsafe conditions or code violations are noted.

The warranty holder or a roofing contractor certified by the roof manufacturer shall inspect the PV systems to ensure the integrity of the installation. To ensure compliance with provisions of the NEC, an inspection by a licensed electrical inspector is mandatory after construction is complete.

Final Drawings Requirements

The Contractor shall hire a third-party commissioning authority to review and comment on the design prior to construction. The Contractor may not proceed with construction until approval of the design submittal has been received from the Government.

The Contractor shall maintain a set of drawings for each of the PV systems, with all Government-approved design changes made during construction. Upon completion of construction, the Contractor shall submit final design documents, including, at a minimum, drawings that are updated to reflect all changes, with details of PV system structural support, any roof penetrations, electrical single-line diagrams, and complete product literature for review by the Government. A structural professional engineer shall sign and stamp the structural drawings, and a professional electrical engineer shall sign and stamp the electrical drawings. Five hard copies shall be submitted, as well as a CD with electronic copies of all documents.

PV System Acceptance Testing

The Contractor shall conduct inspection and testing of each of the PV systems in accordance with its own quality-control plan and the following:

- *Manufacturer recommendations*
- *IEC 62446, Grid Connected Photovoltaic Systems Minimum Requirements for System Documentation, Commissioning Tests and Inspection*
- *The International Code Council (www.ICCsafe.org) Acceptance Criteria 286 for Roof Flashing for Pipe Penetrations and Acceptance Criteria 428 for Module Framing Systems Used to Support PV Modules*

The Contractor shall hire a third-party commissioning authority to provide the visual inspection, array testing, and whole-systems testing specified in IEC 62446. The PV systems shall be tested and accepted as they are completed.

The Contractor shall notify the Government not less than five (5) Business Days prior to the anticipated date of each PV System Acceptance Testing. The Government shall have the right, but not the obligation, to be present at and observe the System Acceptance Testing, at the Government's sole cost.

Acceptance shall be after the PV systems has generated electric energy for ten (10) continuous days at energy and power production levels consistent with the proposed PV system's estimated production with 100% system availability, measured with applicable instruments and meters; the PV system has been commissioned per IEC 62446 and approved for interconnected operation. At that time, the Contractor shall send a Completion Notice and a copy of the System Acceptance Testing to the Contracting Officer so that the Government can complete its final inspection.

The Contractor shall conform to the requirements of FAR Clause 52.246-4, Inspection of Services – Fixed-Price, which is included by reference in this solicitation and Contract. The Government Contracting Officer or the delegated Contracting Officer's Representative may inspect the PV systems at any time during construction or after the PV systems have been put in operation, with a minimum 48-hour notice. The Contractor may be ordered to stop work or shut the systems down if unsafe conditions or code violations are noted.

The warranty holder or a roofing contractor certified by the roof manufacturer shall inspect the roof after installation to ensure roof integrity and compliance with the International Code Council (www.ICCsafe.org) Acceptance Criteria 286 for Roof Flashing for Pipe Penetrations and Acceptance Criteria 428 for Module Framing Systems Used to Support PV Modules. The Contractor shall comply with all Section C requirements, and an inspection by a licensed electrical inspector is mandatory after construction is complete.

Some commissioning activities may commence before the system is operational. After the electrical commissioning agent gives permission for either interim testing for operation in parallel with the electrical utility system is granted, the Contractor shall complete commissioning and acceptance testing of each of the PV systems, in accordance with its own quality-control plan, manufacturer recommendations, utility interconnection requirements, and IEC 62446 Grid Connected Photovoltaic Systems Minimum Requirements for System Documentation, Commissioning Tests and Inspection.

The Contractor shall notify the Government not less than five (5) Business Days prior to the anticipated date of each PV System Acceptance Testing. The Government shall have the right, but not the obligation, to be present at and observe the System Acceptance Testing, at the Government's sole cost.

Acceptance shall be after the PV systems has generated electric energy for ten (10) continuous days at energy and power production levels consistent with the proposed PV system's estimated production with 100% system availability, measured with applicable instruments and meters; the PV system has been commissioned per IEC 62446 and other requirements as specified above; and the PV system has approved for interconnected operation by serving utility. At that time, the Contractor shall send a Completion Notice and a copy of the System Acceptance Testing to the Contracting Officer so that the Government can complete its final inspection.

If any of these requirements are not met, then the Government shall provide Contractor with a detailed notice of such failure (a "Rejection Notice") within the ten (10) Business Day period, and Contractor shall promptly remedy at Contractor's cost the relevant, specified failure and conduct new System Acceptance Testing until it indicates that the PV systems meets the requirements. In each such case, the Contractor shall send a new Completion Notice to the Government with a copy of the results of the new System Acceptance Testing as provided above, and the foregoing procedures shall be repeated.

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Attachment 1 – Comment Form

Attachment 1 – Solar PV Tech Spec Template – Industry Comment Form

Commenter Name__________________Commenter Company______________________

Date of Comments _/_/_

#	Section Number	Page Number	Comment

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