

**ALBUQUERQUE PUBLIC SCHOOLS**

Facility Design & Construction / Maintenance & Operations

**SOLAR PHOTOVOLTAIC SYSTEM**

**DESIGN GUIDELINES**

**Including:**

**Design Parameters**

**Sheet Notes**

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TABLE OF CONTENTS

[INTRODUCTION: 3](#_Toc400005375)

[Design Professional’s Responsibilities: 3](#_Toc400005376)

[Installer’s Responsibilities: 3](#_Toc400005377)

[PV ARRAY GOALS: 3](#_Toc400005378)

[CONTRACT INSTRUCTIONS: 4](#_Toc400005379)

[KEY ARRAY ATTRIBUTES: 4](#_Toc400005380)

[Panels (Modules) 4](#_Toc400005381)

[Panel Performance Degradation 4](#_Toc400005382)

[Tilting 4](#_Toc400005383)

[Spacing 4](#_Toc400005384)

[Shading 4](#_Toc400005385)

[Flat Roof Mounting 4](#_Toc400005386)

[Sloped Roof Mounting 5](#_Toc400005387)

[Inverters 5](#_Toc400005388)

[Warranties 5](#_Toc400005389)

[Training 5](#_Toc400005390)

[OTHER CONSIDERATIONS: 6](#_Toc400005391)

[APPENDIX 1 7](#_Toc400005392)

[SOLAR PHOTOVOLTAIC SYSTEM SHEET NOTES 7](#_Toc400005393)

# INTRODUCTION:

This APS Solar PV Guideline has been developed to:

1. identify the criteria for Solar Photovoltaic (PV) installations at APS facilities and
2. provide guidance to design/construction installers of our PV projects.

It outlines the key attributes of, and expectations for, PV systems on APS projects. Though PV may not be viable in every circumstance, it is the District’s intent to incorporate solar power whenever and wherever practical.

Any deviations from these Guideline criteria shall meet Levelized Cost of Energy (LCOE) requirements. Should proposed deviations incur additional cost, LCOE calculations must be provided including itemized assumptions for panel degradation, utility escalation, and inflation. The LCOE of proposed deviations must be less than or equal to the LCOE of original requirements. Use the link below to calculate LCOE:

***DOE/NREL Calculator:*** <http://www.nrel.gov/analysis/tech_lcoe.html>

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## Design Professional’s Responsibilities:

The Design Professional shall provide a preliminary drawing labeled “PV-100” showing the proposed location and layout for both PV panels and inverter(s).  The drawing shall include a one line electrical diagram for the PV system and its interface to the local electrical utility, and shall incorporate the Sheet Notes that are referenced by this Guideline. The drawing shall also identify the target percentage of anticipated project electrical energy use to be offset by the PV system.

## Installer’s Responsibilities:

The PV Installer shall be directed, via the Design Professional’s preliminary drawing, to design, construct and connect a solar PV system to the local electrical utility, on a turn-key basis.

# PV ARRAY GOALS:

1. Maximize onsite renewable energy generation based on available space, targeting up to 100% of project’s electrical energy use.
2. Minimize penetrations through the roof membrane to facilitate future re-roofing.

Roof-mounted grid-tied systems are preferred (versus ground- or trellis-mounted) to minimize vandalism, reduce first costs, provide protection to roof membranes, and allow for ease of maintenance. Battery storage systems are not allowed due to maintenance and disposal of batteries, unless approved as an exception for load balancing or other reasons.

# CONTRACT INSTRUCTIONS:

* Provide as a turn-key Bid Lot item until further notice by APS.
* Energy monitoring dashboards & sub-metering equipment shall be included in the Bid Lot.
	+ Monitoring shall include irradiance as well as power output.
	+ For large systems (over 250kW), provide monitoring at combiner level (or inverter level if multiple inverters are used without external combiners) in order to monitor sub-system performance.

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# KEY ARRAY ATTRIBUTES:

The following attributes shall be used to plan new PV systems, including panel layout and Basis of Design criteria. A supporting document with Sheet Notes for construction drawings, attached below, is integral to this Guideline. The Sheet Notes must be included in all Construction Documents, outlining the requirements for equipment selection, installation, maintenance, and other considerations.

* Panels (Modules)
	+ Minimum Panel Efficiency: 16% (Year 1 – see degradation requirements below)
	+ Basis of Design: Trina, Canadian, LG, Hyundai, SunPower, or approved equal
* Panel Performance Degradation
* Minimum 90% original capacity at Year 10
* Minimum 80% original capacity at Year 25
* Tilting Requirements
	+ For systems <= 100 KW Fixed Tilt
	+ For systems > 100 KW Single-Axis Tilt may be considered, but only allowed upon review and approval by the Owner
* Spacing and parapet clearance requirements must comply with the City of Albuquerque’s Fire Department PV Guidelines (separate document)
* Shading by objects (structure, trees, etc.) shall be managed so that shade on modules is minimized or eliminated during the hours of 9:00 am and 3:00 pm all days of the calendar year
* Flat Roof Mounting
	+ Ballasted racking system, set at 10⁰ Tilt from horizontal
		- Unirac® as Basis of Design – Use Unirac’s RM tools to size structural loads and determine gear associated with the array
	+ Design to dead load of 4 lb. – 8 lb. per sq ft for racking, ballast, and modules; consult with APS Project Manager if outside this range
	+ IMPORTANT: Coordinate PV ballast specification with roof warranty provisions for PV, especially regarding prescribed sacrificial padding layers (when required)
		- Consider insulated light-weight concrete deck to avoid depressions in roof insulation above the structural decking
	+ Ideal orientation is South, though SE or SW variations are allowable after further review with APS Project Manager
* Sloped Roof Mounting
	+ Schletter “Standard Flush-Mount” Clips & Racking as Basis of Design
* Inverters – *Based upon system size*
	+ Minimum Inverter Efficiency: 97% (year 1). See degradation requirements below.
	+ Indoor inverter placement is preferable, in proximity to the PNM net-meter and REC meters; do not place exterior-rated inverters on south or west facades
	+ Inverter capacity must be >= 105% of array DC Standard Test Conditions (STC) Wattage
	+ Consider string inverters where possible, to reduce need for combiner boxes.
	+ Quantities and sizes:
		- < 50 KW capacity: 2-3 equally sized inverters (if possible given roof layout and interconnection voltage)
		- Between 50 and 100 KW capacity: 3-5 equally sized inverters (if possible given roof layout and interconnection voltage)
		- > 100 KW capacity: approx. one inverter per 20-30 KW capacity, equally sized
		- no single inverter to exceed 40 KW.
	+ Basis of Design: ABB (Power-One), Solectria, SMA, or approved equal.
	+ NOTE: Central inverters appear to be becoming obsolete for designs with power output under 250kW. String inverters allow for greater efficiency and less downtime in case of inverter fault. These inverters may also be installed on the roof since they are much lighter than central inverters.
* Minimum Component Warranties
	+ PV Panel Performance – 25 Years
	+ PV Panel Components – 10 Years
	+ Inverter(s) – 10 Years
	+ Racking – 10 Years
	+ Workmanship – 5 Years
* Training
	+ APS Maintenance & Operations personnel shall be thoroughly trained by the installing PV Contractor and/or manufacturer on the following:
	+ System components
	+ Maintenance
	+ Trouble-shooting
	+ Monitoring
* Training shall be coordinated with and verified by APS commissioning agent

# OTHER CONSIDERATIONS:

* Where existing trellis structures are in place, the design team’s structural engineer shall be consulted to determine whether it can be used to support an array.
* Where project roof surfaces are too small to offset >10% of annual energy costs:
	+ Ultra-high efficiency panels may be considered to increase the annual energy production per square-foot. Provide cost-benefit analysis.
	+ FD&C Project Manager may also evaluate potential use of existing roof surfaces adjacent to a new construction project. Note: applicable codes may restrict mounting on adjacent buildings.
* System layouts are required prior to Construction Documents, illustrating spacing requirements, Fire Department compliance, and the avoidance of array inter-row shading (goal less than 1% annually).

# APPENDIX 1

## SOLAR PHOTOVOLTAIC SYSTEM SHEET NOTES

Special Sheet Notes for PV System as Bid Lot:

1. The photovoltaic (PV) system shall be priced as separate Bid Lot by the design-build photovoltaic contractor. Refer to architectural specifications for exact alternate number.
2. Base Bid for project (General Contractor’s scope) shall only include two (2) 3” conduits from main electrical room to penthouse for future use. Label both conduits at stub-out locations with “Rooftop Solar.”

PV System Sheet Notes:

1. All material and labor for the installation of the roof-mounted photovoltaic array and associated monitoring system shall be included as a turn-key package.
2. Shop drawings shall be submitted and approved prior to the installation of any equipment. Shop drawings shall include general configuration of the system, wire and fuse sizes, proposed monitoring system, all necessary structural calculations, and cut-sheets for related equipment furnished by the Electrical Contractor.
3. PV Contractor must be certified as a North American Board of Certified Energy Practitioners (NABCEP) Solar Installer. Contractor must also hold a current NM EE-98 electrical license.
4. Design/build system shall be in compliance with minimum requirements listed for solar panels, inverters, and energy production as outlined in APS Solar PV Design Guidelines. This document also outlines Basis of Design information to provide a baseline for equipment selection and location. PV panel layouts must be coordinated with Structural and other disciplines. Any revised layout of equipment or panels must be approved by the project engineer and/or architect, be coordinated with other trades, and cause no additional cost to the Owner.
5. Contractor shall provide a detailed system performance and life-cycle summary with their bid (including all soft-costs such as metering, monitoring, etc.), to demonstrate expected payback schedule.
6. Contractor shall provide two (2) site visits during the first year installation warranty period to perform inspection of electrical equipment and analysis of actual power production versus expected, including any cleaning and maintenance of solar panels needed for optimal energy generation.
7. Photovoltaics shall be an included system for overall project commissioning. PV Contractor shall coordinate their commissioning/startup activities with Owner’s commissioning agent.
8. Prior to installation, each module (panel) shall be confirmed to have a production tolerance within 0% to +3% of the module’s nameplate rating (to reduce “module mismatch”).
9. All electrical components including overcurrent protection, disconnects, conduit, wiring and terminals must have UL or equivalent listing, and have appropriate voltage, current and temperature ratings for the application. All wire management materials (cable ties, etc.) utilized outdoors must be of U/V-resistant material.
10. Wiring shall be sized to minimize voltage drop to less than 3% from the PV modules to the inverter, and less than 3% from the inverters to Main Switch Board (MSB).
11. All wiring shall be listed for a minimum operation of 600 volts and 90o C temperature rating. Minimum conductor size is #12 AWG. All current-carrying conductors must be enclosed in conduit, with the exception of module interconnections protected underneath panels within the same grouping.
12. Exposed conduit outside building shall be routed to minimize visibility and painted to match surrounding structure. Conduit shall be routed parallel and perpendicular to structural elements.
13. Equipment shall be labeled to indicate usage, voltage, and all safety/hazard warnings as required by National Electric Code (NEC) section #690, and per local utility company and Authority Having Jurisdiction (AHJ) directives.
14. All framing members, boxes, metal enclosures, panel boards, inverters, and conduit must be properly grounded and terminated at appropriate grounding rod connection point. Modules shall be bonded to support racks using stainless steel hardware (nuts, lock washers, and threaded bolts or other UL listed clamps). Bonding points shall be abraded immediately prior to lugs being fastened in place.
15. For flat roof-top applications, provide UNIRAC® RM roof-mount racking system or approved equal. Racking system shall be ballasted type without roof penetrations. Provide all necessary mounting accessories for installation upon the designed building structure.
16. Provide all necessary components to give a complete and operable system in compliance with the National Electric Code. Ensure that PNM interconnection requirements are met.
17. Contractor is responsible for processing interconnect agreement with PNM, as well as providing all information required to pursue Renewable Energy Credits (RECS) for the Owner. Coordinate with Owner to obtain required signatures on application(s).
18. Provide necessary data connections and equipment for web-based monitoring of inverter output. Owner will provide open internet access for PV monitoring system. Owner will provide data drop (jack) in agreed-upon location.
19. PV system shall be provided with solar radiation/isolation, ambient temperature, and solar cell temperature sensors. These devices shall be integrated with monitoring system to analyze PV system output.
20. Provide suitable computer and separate flat-screen monitor in building lobby or other identified area for PV data display. Coordinate exact location with Owner. Computer must have all necessary monitoring system software pre-installed. Provide written instructions for how to access and navigate PV data at this terminal. Data network access to be provided by Owner.
21. Comprehensive training on PV system by the installer and/or manufacturer’s rep, including PV components, maintenance, monitoring and trouble-shooting, shall be provided to the APS M&O staff and verified by the Owner’s commissioning agent.

One-Line Diagram / Flag Notes:

1. If inverter is not equipped with integral fused string combiner, provide switched combiner box(es) with integral DC disconnect, surge suppression device, and NEMA 3R enclosure (Eaton® #ESC series or approved equal). Provide fused inputs as indicated (Littelfuse® SPF series or approved equal). Fuses shall be sized based on final solar panel selection in accordance with the NEC.
2. All circuit breakers in electrical panel shall be rated as suitable for backfeed. Circuit breakers shall be sized based on final inverter selection and total PV output in accordance with the NEC.
3. PV system circuit breaker at point of interconnection to be provided by PV Contractor. Confirm sizing of breaker at Main Switch Board (MSB) with final configuration of PV system. If MSB cannot accommodate PV on load side, consider line (supply) side connection. Coordinate with project Electrical Engineer.
4. PV system to be monitored, capturing irradiance as well as power output. For large systems (over 250kW), provide monitoring at combiner level (or inverter level if multiple inverters are used without external combiners) in order to monitor sub-system performance. Any associated sub-meter(s) shall be Ethernet capable and measure kW, kWH, and power factor. Tie all sub-meters into central PV monitoring system.