FLORIDA SOLAR ENERGY CENTER®

FSEC STANDARD

Procedures for Photovoltaic System Design Review and Approval

FSEC Standard 203-17

July 2017

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A Research Institute of the University of Central Florida

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1.0 Scope

This evaluation covers any type of photovoltaic (PV) system that is either interconnected with the utility grid or is a stand-alone system that falls within the parameters described below. These system evaluations are based on the complete design and documentation packages that accompany the application for design review. Items evaluated include safety and code compliance of the overall design, individual components and their interactions with one another, and completeness of instructions, diagrams and schematics for system installation, operation and maintenance. This review and approval procedure does not cover site-specific requirements or issues, nor do these approvals replace or exempt any requirements of electric utilities or local jurisdictional authorities such as permitting, inspections or utility interconnection agreements as required for PV system installations.

2.0 Definitions

The terms defined below have the given meaning in this document and the procedures described herein.

Alternating Current (AC): Waveform characteristic of electrical power produced from rotating machinery, typical for utility generation, transmission and distribution of power.

Allowable DOD: The maximum percentage of full-rated battery capacity that can be operationally withdrawn from it, dictated by the cut off-voltage and discharge rate.

Ampere-Hour (Ah): Common measure of a battery's electrical storage capacity. An ampere-hour is equal to the transfer of an average of one ampere of current over one hour period. A battery that discharges 5 amps for 20 hours delivers 100 ampere-hours.

Array: A group of panels (modules) that comprises the complete PV generating unit or system.

Average Daily DOD: The percentage of the full-rated battery capacity that is withdrawn from it with the average daily load profile.

Autonomy: A term used to describe the period the electrical load can operate with the given battery storage capacity in a PV system. Determined by the load current and the battery capacity from full state of charge to the load disconnect point, with no input from the PV array.

Balance of System (BOS) Components: A term used to describe components other than the major PV system components (PV modules, inverters and storage devices), including but not limited to: conductors and terminations; disconnects and overcurrent protection devices; grounding and surge protection equipment; support structures and enclosures; auxiliary systems; and instrumentation and monitoring equipment.

Batteries and Battery Bank: An electrochemical energy storage and delivery system, used in PV systems to store the energy produced by the PV array, and to provide back-up power to on-site loads or to feed the utility grid.

Battery Capacity: A measure of a battery's ability to store and deliver electrical energy. Commonly expressed in units of ampere-hours (Ah) at a specified temperature, discharge rate and cut-off voltage. Design features that affect battery capacity include quantity of active material; number, design and physical dimensions of the plates; and electrolyte specific gravity. Operational factors that affect battery capacity include discharge rate; depth of discharge; cut off voltage; temperature; battery age and cycle history.

Blocking Diode: Placed in series with a module or "string" of modules to prevent reverse current flow and protect PV modules. Conducts current during normal operation. Can be used to prevent discharge of batteries at night in stand-alone systems.

Bypass Diode: Also called "shunt" diodes, used to pass current around, rather than through a group of cells or modules. Permit the power produced by other parts of the array to pass around groups of cells or modules that develop an open-circuit or high resistance condition.

Charge Controller Algorithm: Defines the way the charge controller regulates the array charging of the battery. Common types include series, shunt, on-off (interrupting), constant-voltage and pulse-width-modulated (PWM).

Cut-Off Voltage: The lowest voltage that a battery is allowed to reach in nominal operation, defining the battery capacity at a specific discharge rate.

Cycle: Refers to a discharge to a given depth of discharge followed by a complete recharge. A 100 percent depth of discharge cycle provides a measure of the total battery capacity.

Depth of Discharge (DOD): The percentage of battery capacity that has been withdrawn from it compared to the total fully charged capacity.

Direct Current (DC): A unidirectional current or signal in an electrical circuit, usually represented with a positive and negative polarity. Photovoltaic cells and batteries are direct current (DC) devices.

Efficiency (%): The ratio of the the average output and input power of an energy conversion system. Photovoltaic module and array efficiency is defined as the maximum power output of the module/array divided by the available power from the irradiance and array surface area.

FSEC: The Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, Florida 32922-5703. FSEC is one of research centers of the University of Central Florida (UCF).

Grid-Connected Photovoltaic Systems: An electrical power generating system that uses a photovoltaic (PV) array as the primary source of electricity generation, and is intended to operate synchronously (frequency and voltage) and in parallel with the electric utility network. Such systems may also include battery storage, other generating sources, and may operate on-site loads independent of the utility network during outages.

I-V Curve: Represents the current-voltage (I-V) performance of a photovoltaic cell, module or array at a given operating temperature and solar irradiance.

Innovative Equipment: Photovoltaic systems and/or equipment which, due to its design, cannot be evaluated adequately and fairly by methods described in this document.

Insolation (solar radiation): The energy flux from the sun received on a unit surface area, usually expressed in units of kWh/m^2-day for the average daily or monthly conditions at a given location. For a given location, the amount of insolation received defines the maximum energy production of a photovoltaic array.

Inverter: A power conversion device that transforms DC power into AC power at specified voltage and frequency. Can operate directly from either PV arrays or batteries, and produce AC power to operate loads independently, or operate interconnected to and in parallel with the utility grid. Typically wide range of inverters are commercially available, from few kWs to 100's of kW's. When the inverter rated power is at the PV module level (200W-300W) the inverter is known as a **micro-inverter**.

Interconnection: The technical and administrative process by which PV systems and other distributed generators are connected to and operated in parallel with the electric utility network.

Irradiance: The instantaneous solar power or rate of solar flux received on a unit surface area, generally expressed in units of watts per square meter (W/m^2). A typical peak value for irradiance at noon on a clear day, on a surface normal to the sun's rays is 1000 W/m^2.

Junction Box: An enclosed terminal block on the back of PV modules or in other parts of a system, which allows the modules/array and other subsystems to be connected electrically in the system.

Low Voltage Disconnect (LVD): The battery voltage at which a controller disconnects the load, defining the maximum DOD.

Low Voltage Disconnect Hysteresis (LVDH): The voltage between the LVD and the voltage at which the load is reconnected.

Major System Components: Includes the photovoltaic (PV) modules and array, batteries, system controller and inverter, as applicable.

Maximum Power (Pmp): The maximum power output of a photovoltaic cell, module or array when operated at its highest efficiency point, corresponding with the maximum power current and voltage (Imp and Vmp).

Maximum Power Current (Imp): The current output of a photovoltaic cell, module or array when operated at its maximum power point, corresponding with the maximum power voltage (Vmp).

Maximum Power Voltage (Vmp): The voltage output of a photovoltaic cell, module or array when operated at its maximum power point, corresponding with the maximum power current (Imp).

Maximum System Voltage: The maximum rated voltage for a PV system, based on the rated open-circuit voltage of the array, and adjusted for the lowest ambient temperature at the installation site. Used to determine acceptable ratings for electrical devices used in the system.

Model: A photovoltaic system or component that is distinguished by a specified size, set of materials, configuration and performance. A change in any of these basic characteristics constitutes a new model.

Module: A group of PV cells connected in series and/or parallel and encapsulated in a laminate. The basic building block for PV arrays.

Nominal Operating Cell Temperature (NOCT): A reference temperature of a photovoltaic module or array, operating at an irradiance level of 800 W/m^2, an ambient temperature of 20^o C, a wind speed of 1.0 m/s, and with the module or array in open-circuit condition.

Open-Circuit Voltage (Voc): The maximum voltage output of a photovoltaic cell, module or array; measured in an open-circuit condition.

Panel: A group of interconnected cells and modules that is the basic building block for installing PV arrays.

Peak Sun Hours: See *Insolation*

Power Optimizer: A DC to DC conversion device designed to optimize the power output of a photovoltaic panel. Typically, these are module level electronic devices (integrated or add-on) that perform maximum power point tracking and panel isolation. The Power Optimizer is also known as DC or Panel Maximizer.

Rate of Charge/Discharge: The current flow into or out of a battery. Expressed as a ratio of the nominal battery capacity to the charge or discharge time period in hours.

Regulation Voltage (VR): The maximum voltage the controller allows the battery to reach before the array is disconnected.

Regulation Voltage Hysteresis (VRH): The voltage span between the VR and the voltage at which the array is reconnected to the battery.

Short-Circuit Current (Isc): The maximum current output of a photovoltaic cell, module or array; measured in a short-circuit condition, and directly proportional to the solar irradiance.

Stand-Alone Photovoltaic System: A solar photovoltaic system that supplies power independently of an electrical production and distribution network.

Standard Operating Conditions (SOC): A secondary reference condition for the performance ratings of photovoltaic modules and arrays. Based on a solar irradiance of 1,000 W/m^2, nominal operating cell temperature (NOCT) and under the ASTM standard G173 air mass (AM) 1.5 global spectrum. SOC represents a more typical temperature condition for PV modules and arrays operating in the field.

Standard Test Conditions (STC): The industry accepted primary reference condition for the performance ratings of photovoltaic cells, modules and arrays. Based on a solar irradiance of 1,000 W/m^2, a PV cell temperature of 25^o C, air mass 1.5 and under the ASTM standard spectrum (AM 1.5). Seldom do PV devices operate at STC, rather actual measurements are translated to these conditions for the purposes of ratings and comparison between different modules and arrays.

Standard: A document that specifies the performance, test procedures, durability or safety requirements for a system or component.

State of Charge (SOC): The amount of energy in a battery, expressed as a percentage of the energy stored in a fully charged battery.

System Approval: The process outlined in this standards document that provides a method for evaluating the suitability of PV system design packages**.**

System Controller: The device or combination of devices in a PV system that regulates the state of charge of the battery subsystem and may also provide load control functions.

System Manual: The complete documentation package accompanying an approved PV system design. Must be submitted for design review, and include at a minimum, electrical and mechanical drawings, parts/source lists, manuals for major components (modules, inverters, etc.), and instructions for installation, operation and maintenance of the system.

Total Dynamic Head: The vertical distance from the center of the pump to the point of free discharge of the water. Pipe friction is included.

4.0 System Classifications

The design review process focuses on two categories of photovoltaic systems: grid-connected and stand-alone.

4.1 Grid-Connected Systems

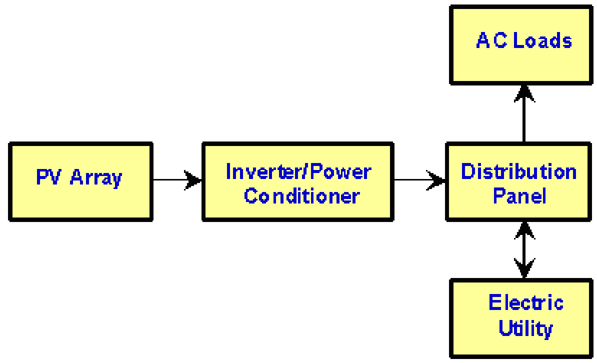
Two types of grid-connected photovoltaic systems are considered in this FSEC standard. These include grid-connected PV systems without battery storage and grid-connected PV systems with battery storage. For the purposes of this document and the scope of the design review and approval process, the following is the intended definition of a grid-connected photovoltaic system:

"An electrical power generating system that uses a photovoltaic (PV) array as the primary source of electricity generation, and is intended to operate synchronously and in parallel with the electric utility network. Such systems may also include battery storage, other generating sources, and may operate on site loads independent of the utility network during outages."

There are three types of stand-alone systems covered by this document. These include PV-powered water pumping systems, PV-powered lighting systems, and remote residential PV systems.

4.1.1 Grid-Connected PV Systems without Battery Storage

Grid-connected or *utility-interactive* PV systems are designed to operate in parallel with and interconnected to the electric utility grid. The primary component in grid-connected PV systems is the *inverter*, or *power-conditioning unit* (PCU). The PCU converts the DC power produced by the PV array into AC power consistent with the voltage and power quality requirements of the utility grid, and automatically stops supplying power to the grid when the utility grid is not energized. A bi-directional interface is made between the PV system AC output circuits and the electric utility network, typically at the on-site distribution panel or service entrance. This allows the AC power produced by the PV system to either supply on-site electrical loads, or to supply power to the grid when the PV system output is greater than the on-site load demand. At night and during other periods when the electrical loads are greater than the PV system output, the balance of power required by the loads is received from the electric utility. When the utility grid is down, these systems automatically shut down and disconnect from the grid. This safety feature is required in all grid-connected PV systems, and ensures that the PV system will not continue to operate and feed back onto the utility grid when the grid is down for service or repair.

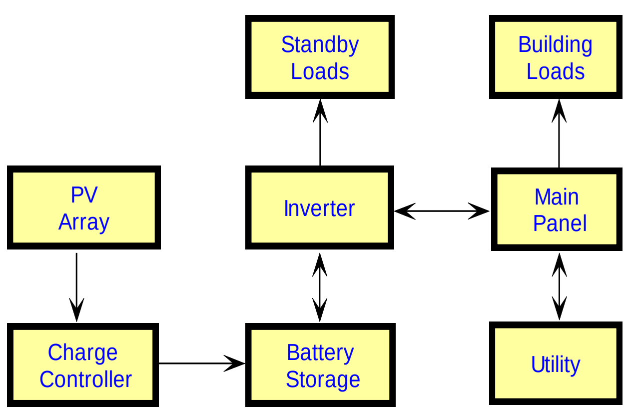


4.1.2 Grid-Connected PV Systems with Battery Storage

This type of system is extremely popular for homeowners and small businesses where backup power is required for standby loads such as refrigeration, water pumps, lighting and other necessities. Under normal operating conditions, the system operates in a grid-connected mode, supplementing the on-site loads or sending excess power back onto the grid while keeping the battery fully charged. In the event the grid becomes de-energized, control circuitry in the inverter opens the connection with the utility through a *bus transfer mechanism*, and operates the inverter from the battery to supply power to the dedicated standby load circuits only. In this configuration, standby loads are typically supplied from a dedicated load sub panel.

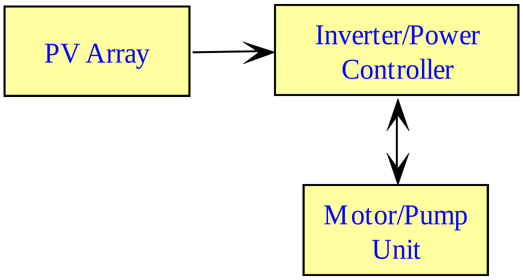
4.2 Stand-Alone Systems

Each of these systems can provide power to DC loads. With the incorporation of an inverter in the system, each can also supply AC loads. Unlike the grid-connected systems, these systems must generate all the power available to the loads. Thus, array sizing (and battery sizing where included) and load requirements are critical aspects of success in meeting the customer's needs.



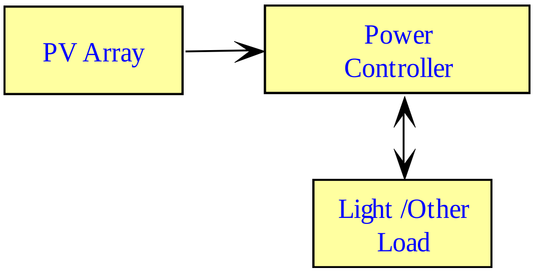
4.2.1 PV-Powered Water Pumping Systems

Water pumping is a major application for PV systems across the western US. Typically, these systems include a ground-mounted array (with or without an optional mechanical tracking device), a pump controller, an inverter for AC pump motors, and the pump/motor assembly operating off either DC or AC. Water is pumped only during daylight hours and is usually stored in a water tank to cover periods of bad weather. Batteries banks also may be incorporated in these systems as well.



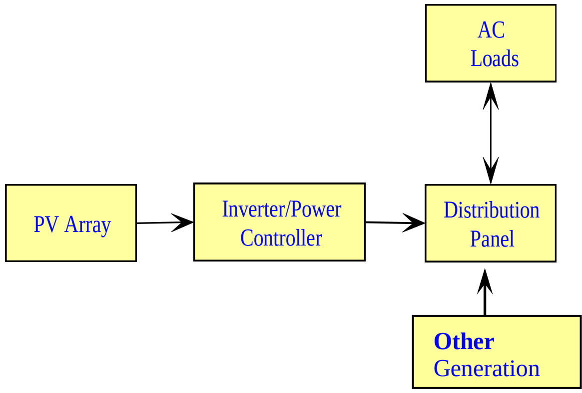
4.2.2 PV-Powered Lighting Systems

Photovoltaic-powered lighting systems are an option for providing area lighting and sign lighting in lieu of extending utility service. These systems are sold as packages including the array, batteries, battery enclosure, charge controller, lighting controller, light fixture, ballast and lamp. The systems are typically small – total module output is typically under 250 W_{STC}. The arrays are usually pole mounted or mounted to the sign structure and should be equipped with vandal resistant hardware. High-pressure sodium, low-pressure sodium, and fluorescent fixtures are popular choices for these lights. Protection of the batteries from significant temperature variations is an important installation issue with these systems. Enclosure provisions for the batteries should moderate any temperature excursions to extend the lifetime and capacity of the batteries.



4.2.3 Remote Residential PV Systems

Photovoltaic systems can power remote residences and other small facilities where utility power is not available or desired. These systems typically utilize a roof or ground mounted array, a battery charge controller, battery storage, and an inverter to supply 115 VAC, 60 Hz electrical service. These systems may also be supplied with an auxiliary source of power such as small wind generators and/or engine generators to meet electrical needs during periods of bad weather. These systems may also be configured as portable power generators, either skid or trailer mounted, and are complete packages with integrated components.



5.0 Criteria for System Approval

Criteria for system approvals are based on applicable codes and standards, and consistency with industry accepted design practices. General criteria include:

- Conformance of the overall electrical design and specified installation methods with all relevant sections of the National Electrical Code (NEC).
- Evidence of applicable product listings for major components from Underwriters Laboratory (UL) or other recognized laboratory.
- Module certification according to FSEC Standard 202 (current version).
- Where battery storage is used, conformance with Applicable codes and standards.
- Warranty information for complete system and individual components.

6.0 Application for Design Review (Manual Review)

Any system integrator, supplier, owner, designer, or installation contractor may initiate the design review process by completing an application form, whether in paper form or online, and submitting all required documentation and materials to FSEC for review. A single application must accompany each system submitted.

Anyone requesting design review and approval should use the National Electric Code (NEC) and the checklist on the application as a guide. More information regarding the process for submitting designs for review is available from FSEC's Internet web site.

The organization or individual submitting the design for approval will be responsible for meeting all criteria by providing the necessary documentation, drawings, schematics, parts lists, manuals, and warranty documentation as applicable. The initial system design review process will be completed in the order applications are received. Applications that are incomplete or inaccurate required will be identified for the applicant, and the designs must be appropriately amended by the applicant prior to approval.

7.0 Grid-Tied Evaluation Process

System manuals, electrical and mechanical drawings, component manuals and other documentation submitted for review will be evaluated according to the requirements of this document. When the review is completed, FSEC will provide the supplier with a report on the evaluation, and note any deficiencies required for approval. After all deficiencies have been resolved, approval will be granted and the supplier will be awarded a *System Approval Certificate.*

7.1 System Documentation Review

A complete system documentation package is a fundamental requirement for system approvals. At a minimum, this documentation must include system specifications, parts lists, and electrical schematics. The supplied documentation is reviewed to verify that the following items are included:

- System description and specifications

- Data sheets for all major components (modules, inverters, etc.)
- Complete electrical schematic
- Warranty information on components and complete system

It is strongly encouraged to provide the following items with the system submittal:

- System installation and checkout procedures
- System operation, maintenance and troubleshooting instructions
- Owner's manuals for individual major components

7.2 Electrical Design Evaluation

Safe and code-compliant electrical designs are a principal concern of these approvals, and must be consistent with the requirements of the NEC. At a minimum, supplier's electrical drawings must include the types, sizes, ratings and locations of all conductors, overcurrent and disconnect devices, terminations and connectors, conduit and junction boxes, and grounding systems. Complete electrical schematics are required for these items. Design documentation, installation instructions and electrical schematics are reviewed to verify that they specify and diagram:

- Types, sizes and locations of all system conductors
- Types, ratings and locations for all required system disconnect and overcurrent devices
- Ratings and locations for blocking and bypass diodes, as applicable
- Requirements for equipment and system grounding and surge suppression
- Methods and equipment required to interface the PV system output with the electric utility grid
- Types, ratings and locations for all conduit and junction boxes
- DC voltage drop limitations and conductors required for given length
- PV module equipment grounding
- PV system grounding
- Charge controller details (if applicable)
- Battery wiring (if applicable)

7.3 PV Modules and Arrays

An important part of the system design reviews is ensuring that quality PV modules are used. Basic requirements include applicable qualification tests and product listings, and manufacturers' specifications. PV modules used in systems submitted for review must be FSEC certified. Module certification does not have to preclude the submittal of an application for system certification but is required for final approval of the design.

7.4 Power Conditioning Equipment

Inverters, chargers, controllers, PV Optimizer, and other power processing hardware are critical components in these approvals, and this equipment must meet industry standards for grid-connected PV systems. Acceptable voltage set points, and other system programming or control set points must also be consistent for the type of batteries used, as applicable. The system documentation and equipment specifications are reviewed for:

- Compliance with current standards UL 1741 and IEEE 929

- Specification and appropriateness of inverter/controller operating windows for PV array under highest and lowest temperature extremes
- Specification and appropriateness of control or programmable set points for charge control with given battery
- Inclusion of owner's, operator's and user's manuals for all major power processing components

8.0 Stand-Alone Evaluation Process

The majority of the criteria for grid-connected systems are also applicable to off-grid system approval. The electrical systems are evaluated for code compliance and sound design principles, the mechanical systems are analyzed for basic stability and function, the components must meet minimum standards and be of the appropriate type and size, and the remainder of the documentation package must clearly communicate instructions for installation, operation, maintenance, etc. Because of the nature of Off-Grid systems, some criteria differ from Grid-Tied systems. These are specific to the intended application of the PV system, and are listed in the following sections.

8.1 PV Water Pumping System

- Systems must be supplied with complete installation, operation and maintenance manuals for utility personnel and a user manual for the utility customer.

- Systems must include two distinct sub-systems including:
  1) a fully integrated PV power supply (PV modules and power controller or inverter) with all hardware needed for installation (excluding water pipe and pump cable), and

  2) the associated pump/motor unit including all wiring, fittings, etc.

- The supplier must provide:
  - performance curves for the pump as a table or chart showing pump output in gallon per minute (GPM) verses power input (W) to the unit for a given Total Dynamic Head (TDH),
  - daily water output for an isolation value of 5kWhr/m^2 per day (5 peak sun hours).

- The pump/motor units may be DC or AC.

8.2 PV Lighting Systems

- Systems must be supplied as complete packages with all hardware and wiring necessary for installation (excluding poles or sign lighting arms and wiring for sign lights).

- Systems must have an appropriate array to load ratio (typically between 1.3 and 1.5).

- All PV system components exposed to the elements must be capable of withstanding exposure to temperatures of -20º to 45ºC and shall be capable of meeting local design wind conditions.

- The supplier must provide each system's light output (foot-candles) and run time at an isolation level of 5 kWh/m^2 per day (5 peak sun hours).

- Systems must be capable of supplying the design energy for the specified period without auxiliary energy based on the low voltage disconnect (LVD) set point during winter temperatures and have a minimum three-year battery lifetime under typical cycling.

- The maximum allowable depth of discharge should be no more than 50 percent of the nominal battery capacity for the given discharge rates, or higher, depending upon the appropriate value for the selected battery technology. The specified LVD set point of the battery charge controller should be consistent with the maximum allowable depth of discharge for the battery.

- Battery charge voltage temperature compensation must be provided as part of the charge controller and the temperature compensation coefficients must be specified.

- Lamps, ballasts and fixtures must be suitable for outdoor application, must be fully described, and must meet a minimum 3-year service life.

- Light fixtures (and lamps) must meet a minimum illumination level of 0.4 foot-candle over a 400 square foot area for the area lighting systems and a minimum illumination of 0.8 foot-candle over the given area for sign lighting systems.

8.3 Remote Residential PV System

- Systems must be capable of supplying the design energy for at least the manufacturer-specified autonomous operation period without auxiliary energy. Compliance will be based on the low voltage disconnect (LVD) set point during winter temperatures, with the battery having a minimum three-year battery lifetime under typical cycling.

- Systems must provide 115 VAC, 60 Hz, single-phase power at a minimum.

- Systems must be supplied as complete packages and with all necessary installation hardware.

- Systems must be capable of operating in temperatures of -20º to 45ºC and shall be capable of meeting local design wind conditions.

- System components/packages must have proven and documented records of field performance and successful operation in similar applications.

- Systems must have NEC approved means for accepting auxiliary 115 VAC power.

- The supplier must provide each system's expected daily AC output (kWh per day) and maximum AC power capability (peak watts) at an insolation level of 5 kWh/m^2 per day (5 peak sun hours) during summer months.

- For systems with batteries, flooded lead-acid batteries are not allowed for installation in any conditioned space or living/working areas of homes or facilities.

- AC output of array should be metered

- Installation completed by individual/organization with recognized competence (i.e., certified by recognized organization, installer trained by system supplier, etc.)

9.0 Express Certification Process

Any system integrator, supplier, owner, designer, or installation contractor may initiate the design review process by utilizing the Express Certification Process in lieu of the manual certification process. FSEC Express Certification is an online tool developed by FSEC to provide system certification while expediting the permitting process for Tier 1 residential roof top solar photovoltaic systems. Express Certification requires data entry of key PV System design parameters; allows selection of PV System components from a pre-approved list; automatically performs required electrical calculations; provides verification that design meets NEC and FBC requirements; produces FSEC certified, code-compliant system; provides electronic or hard copy certified system document package that allows for expedited permitting in jurisdictions that have approved its use.

10.0 Administration

10.1 Personnel

A Design Review Committee (DRC) consisting of designated FSEC staff members evaluates all submittals. DRC members must meet the following qualifications:

- B. S. or higher degree in engineering or equivalent.
- Sound knowledge of relevant sections of the current National Electric Code (NEC), applicable standards, and PV system design and installation practices.
- Minimum of three years' work experience in photovoltaic systems, including at least one year in PV system design.

10.2 Record Keeping

Documentation and archives for all correspondence are kept electronically and in hardcopy in the file room in the FSEC PVDG Division.

10.3 Fees

A fee sufficient to cover the costs of the design review and approval process shall be collected prior to the performance of these services. Fees may be revised as deemed necessary to cover costs. Information on the fee for this service is available at the Center.

10.4 Use of System Approval

Upon request, the system manufacturer, supplier or installation contractor shall furnish a copy of the complete *System Manual* and the *System Approval Certificate* to system owners, code enforcement officials, electric utilities or others involved in purchasing, installing, inspecting, operating or maintaining the system The System Approval Certificate is issued to the individual or entity identified on the Design Review Application and is a document to be under their control. Copies of the certificate will not be issued without approval of the certificate owner. An assembly of similar components, without approved documentation, does not constitute an approved system. An example of a System Approval Certificate is available from FSEC.

Note that these approvals do not replace or exempt any requirements of electric utilities or local jurisdictional authorities in matters such as permitting, inspections or utility interconnection agreements as required for PV system installations. When referring to FSEC approvals in any documentation produced by the supplier, including technical or marketing information, there shall be the following statement:

"The photovoltaic system design described in this manual, when properly installed and maintained, meets the minimum recommended practices established by the Florida Solar Energy Center. This "approval" does not imply endorsement or warranty of this product by the Florida Solar Energy Center or the State of Florida."

10.5 Maintaining System Approvals

A database of approved grid-connected PV systems will be maintained by FSEC and produced on the Internet for public access. To verify the approval status of a PV system design package, an official or other interested party may contact FSEC or access the information via the Internet.

As indicated on the signature form required of all companies submitting a system design, manufacturers and suppliers must contact FSEC when components, configurations, or documentation for approved system are modified. FSEC may evaluate approved designs on a periodic basis to determine if each *System Manual* and the system and components are still accurate and up to date any changes or updates are required. Changes in an approved system that require the approval of FSEC include:

- Changes in the type, model or manufacturer of the photovoltaic modules/arrays, battery bank, inverter or other primary system components
- A change in the system diagram (configuration) or electrical schematic; that is, a change in the arrangement of components in the system, or a change in the ratings of specific components
- Any significant change in the *System Manual*, drawings, electrical components or array mounting hardware or design

10.5.1 Denial of Approval

If FSEC determines that the applicant does not satisfy all the criteria as outlined in this document, FSEC shall give the applicant a written report detailing all reasons for denying approval using the Design Review Checklist and Reporting Form (sample available from FSEC). An applicant aggrieved by the FSEC decision may file a written request for review with FSEC. The FSEC Director shall appoint a Review Committee, which will reconsider the information on file. Based on the Review Committee's findings, FSEC shall, affirm, modify or reverse the initial decision and shall so inform the applicant of the Review Committee's recommendations.

10.5.2 Revocation of Approval

10.5.2.1 Supplier-initiated

The party who has been issued an approval for a photovoltaic system may voluntarily terminate the approval by giving written notice to FSEC. The note shall state the effective termination date and the reasons for termination.

10.5.2.2 FSEC-initiated

FSEC may revoke or suspend an approval for a grid-connected PV system package in the event of:

- Deliberate misrepresentation of documentation submitted in the application for design review and approval
- Claiming that one PV system approval applies to another system which has not been approved
- Failure to comply with a condition of approval or product labeling
- Failure to correct a discrepancy that is detected by FSEC after initial FSEC approval. Supplier will be given 30 days in which to make corrections.

The procedure for appeal of certification revocation shall conform to the process for appeal of denial of certification specified above.