AMERICAN RIVER COLLEGE

Performance, Maintenance, Troubleshooting

Lesson Plan

- Mechanical Design – Any Questions?
- NABCEP Learning Objectives:
  Performance, Maintenance, Troubleshooting

NABCEP Learning Objectives

Category	Course Time By %	Exam Items	Level of Testing	
1. PV Markets & Applications	5%	3	Comprehension	✓
2. Safety Basics	5%	3	Comprehension Application	✓
3. Electricity Basics	10%	6	Comprehension Problem Solving	✓
4. Solar Energy Fundamentals	10%	6	Comprehension Application Problem Solving	✓
5. PV Module Fundamentals	10%	6	Comprehension Application Problem Solving	✓
6. System Components	15%	9	Comprehension Application Problem Solving	✓
7. PV System Sizing Principles	10%	6	Application Problem Solving Design	✓
8. PV System Electrical Design	15%	9	Application Problem Solving Design	✓
9. PV System Mechanical Design	10%	6	Application Problem Solving Design	✓
10. Performance Analysis, Maintenance and Troubleshooting	10%	6	Analysis Problem Solving	
Totals	100%	60		

10.	**Performance Analysis, Maintenance and Troubleshooting** *Suggested Percentage Time Allotment: 10%*	**Learning Priority**
10.1	Discuss various potential problems related to PV system design, components, installation, operation or maintenance that may affect the performance and reliability of PV systems.	Useful
10.2	Identify and describe the use and meaning of typical performance parameters monitored in PV systems, including DC and AC voltages, currents and power levels, solar energy collected, the electrical energy produced or consumed, operating temperatures and other data.	Important
10.3	Compare PV system output with expectations based on system sizing, component specifications and actual operating conditions, and understand why actual output may be different than expected.	Important
10.4	Describe typical maintenance requirements for PV arrays and other system components, including inverters and batteries, etc.	Important
10.5	Understand the safety requirements for operating and maintaining different types of PV systems and related equipment.	Critical
10.6	Identify the most common types of reliability failures in PV systems and their causes due to the equipment, quality of installation and other factors.	Important
10.7	Review component manufacturers' instructions for operation, maintenance and troubleshooting for PV modules and power processing equipment, and develop a simple maintenance plan for a given PV system detailing major tasks and suggested intervals.	Important
10.8	Understand basic troubleshooting principles and progression, including recognizing a problem, observing the symptoms, diagnosing the cause and taking corrective actions leading from the system, subsystem to the component level.	Important

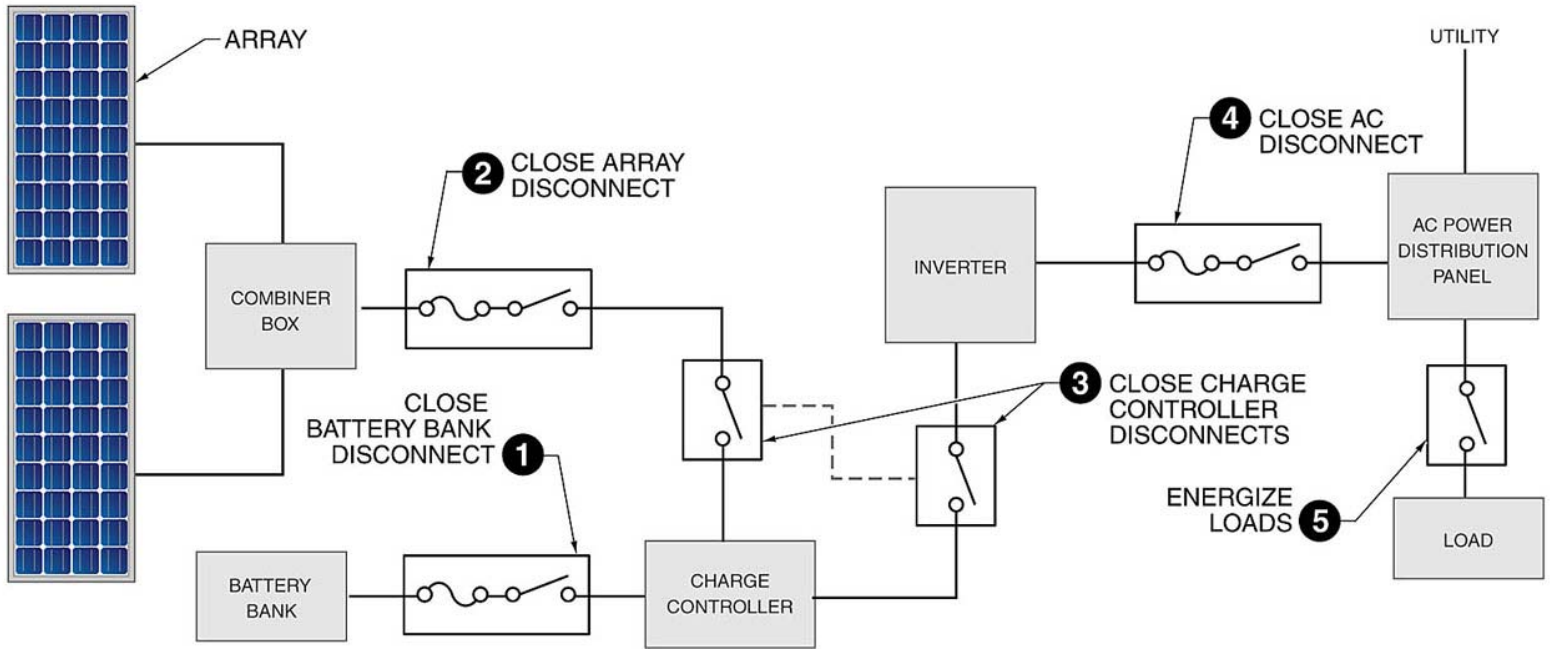
Commissioning Checklist

- ☐ Installation conforms to system-design documents
- ☐ Conductors are of appropriate types and sizes
- ☐ Wiring is correct, protected, and secure
- ☐ Terminal connections are tight and properly identified
- ☐ Equipment is securely mounted
- ☐ Array mounting system is secure
- ☐ Roof penetrations are properly weather sealed
- ☐ Safety features are installed and operational
- ☐ Applicable warning and operational labels are posted
- ☐ Job site is clean, neat, and orderly
- ☐ Documentation package is complete

- A commissioning checklist should be reviewed before the initial startup of a PV system.

- A general start-up procedure begins at the array and ends at the loads.

General Start-Up Procedure



Customer Walkthrough

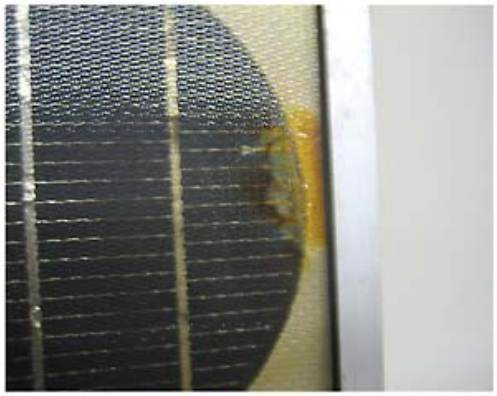
DOE/NREL, Rich Chartier

- A detailed walkthrough allows the installer to explain the basic operation of the PV system and the maintenance requirements to the owner.

- Module inspections involve checking for damage from physical impacts, delamination, burned internal connections, and other problems.

Module Inspection

PHYSICAL DAMAGE



DELAMINATION

BURNED CONNECTIONS

Corroded Grounding Connections

- Corroded grounding connections usually result from the contact of incompatible materials.

- Periodic shading control involves trimming vegetation and cleaning a soiled array.

Shading Control

TREES

SOILING

Mold

- Damp leaf debris trapped under arrays can cause mold and mildew problems.

- Cracked or deteriorated weather sealing around attachment-point penetrations can quickly develop water leaks.

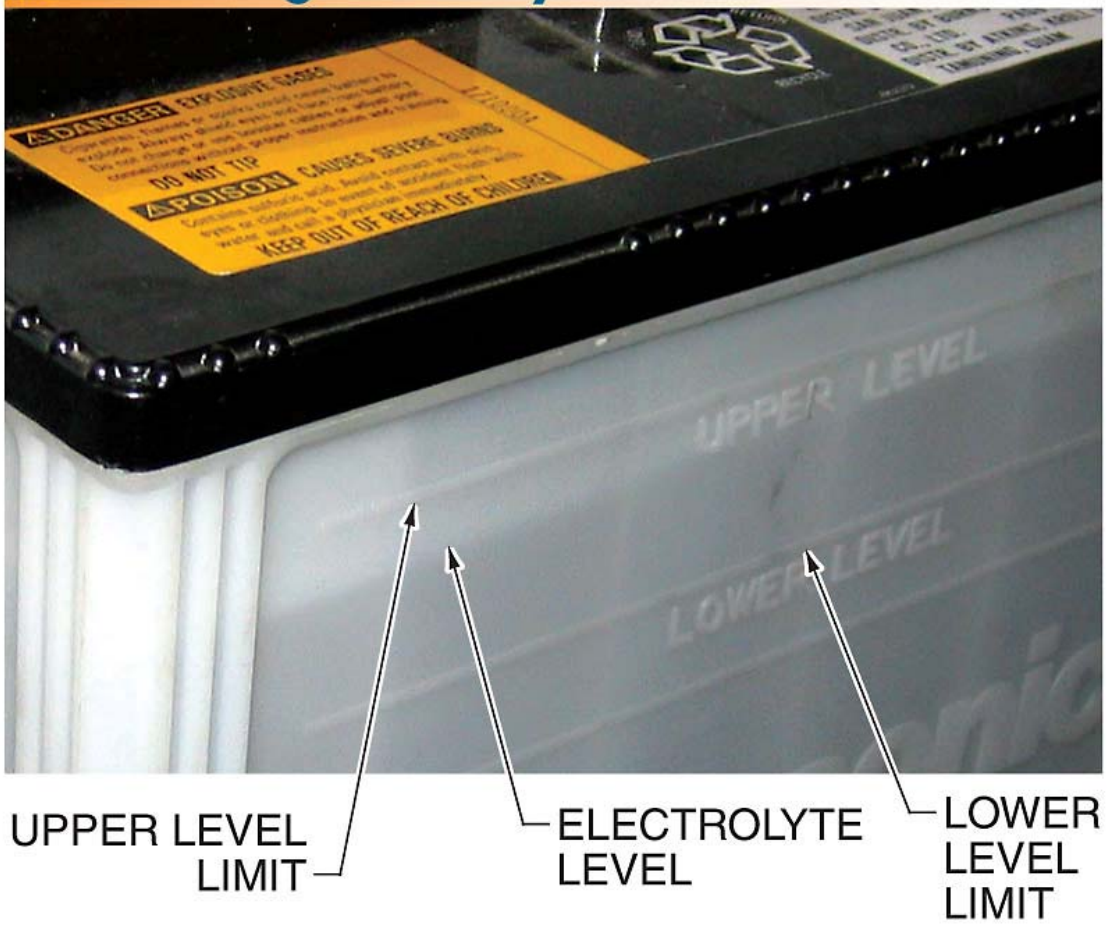
Degraded Weather Sealing

Battery-Terminal Cleaning

- Battery terminals are particularly susceptible to corrosion and may require frequent cleaning.

- Battery maintenance includes checking for an adequate level of electrolyte.

Checking Electrolyte Levels



Watering

- Battery watering replaces water lost from gassing during charging.

- Battery state of charge can be related to both specific gravity and voltage.

Battery State of Charge Measurements

STATE OF CHARGE	ELECTROLYTE SPECIFIC GRAVITY	OPEN-CIRCUIT VOLTAGE
100%	1.265	12.6
75%	1.225	12.4
50%	1.190	12.2
25%	1.155	12.0
0%	1.120	11.8

- Either one of two types of hydrometers can be used to measure the specific gravity of battery electrolyte.

Hydrometers

ARCHIMEDES HYDROMETER

REFRACTIVE INDEX HYDROMETER

Battery Load Tester

- A battery tester indicates a battery's overall health by measuring the battery's voltage under a high-current load.

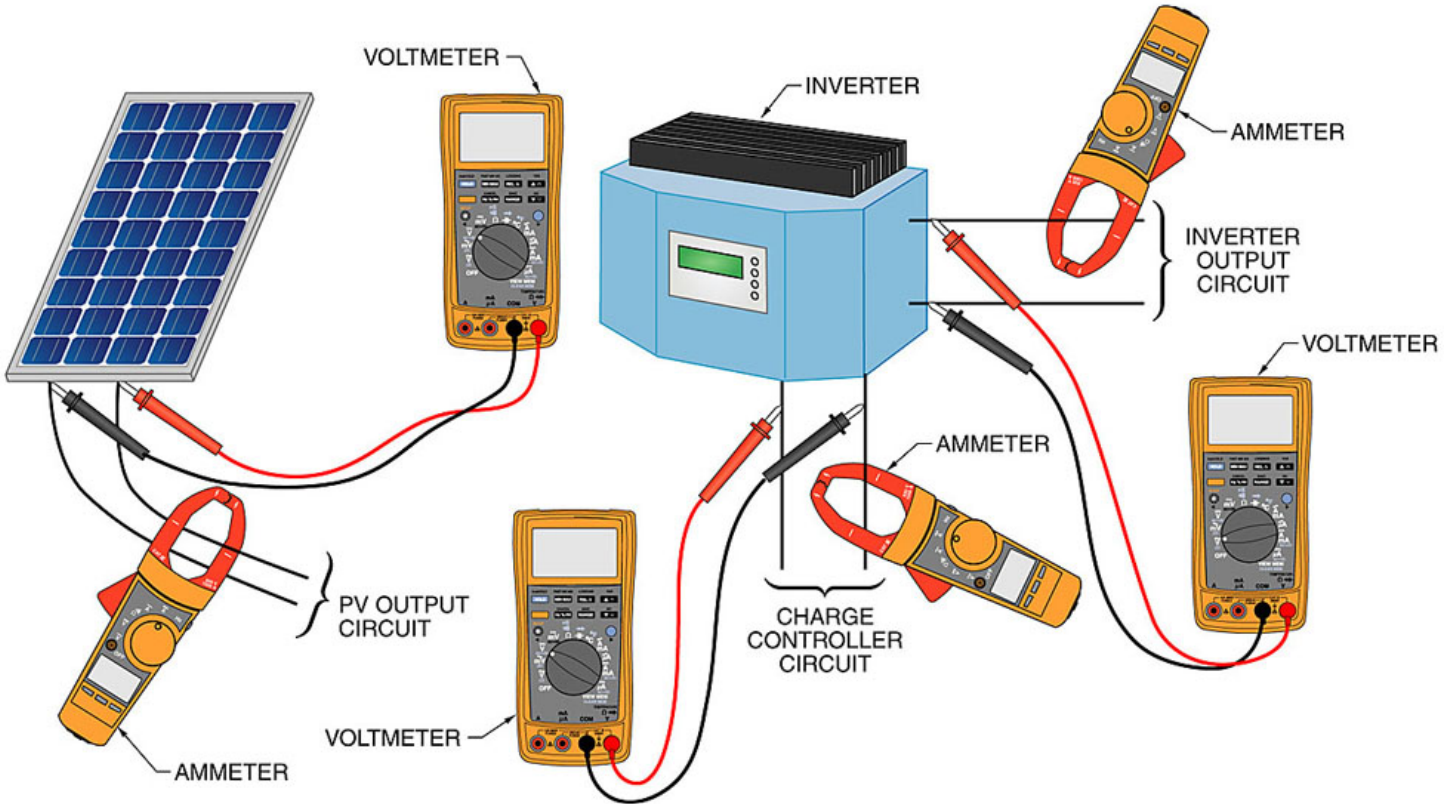
- A maintenance plan includes all the necessary maintenance tasks and their respective schedules.

Maintenance Plan*

TASK	RECOMMENDED INTERVAL		
	As Required	Monthly	Semiannually
Inspect modules for damage			✓
Address array shading issues	✓		
Remove debris around array	✓		✓
Inspect array mounting system			✓
Adjust array tilt	✓		
Check inverter and/or charge controller for correct settings		✓	
Inspect battery enclosure		✓	
Inspect battery terminals and connections		✓	
Equalize batteries	✓	✓	
Water batteries	✓	✓	
Measure specific gravity of each battery cell	✓	✓	
Load-test batteries			✓
Capacity-test batteries			✓
Inspect and clean all electrical equipment			✓
Monitor system for voltage and current	✓	✓	

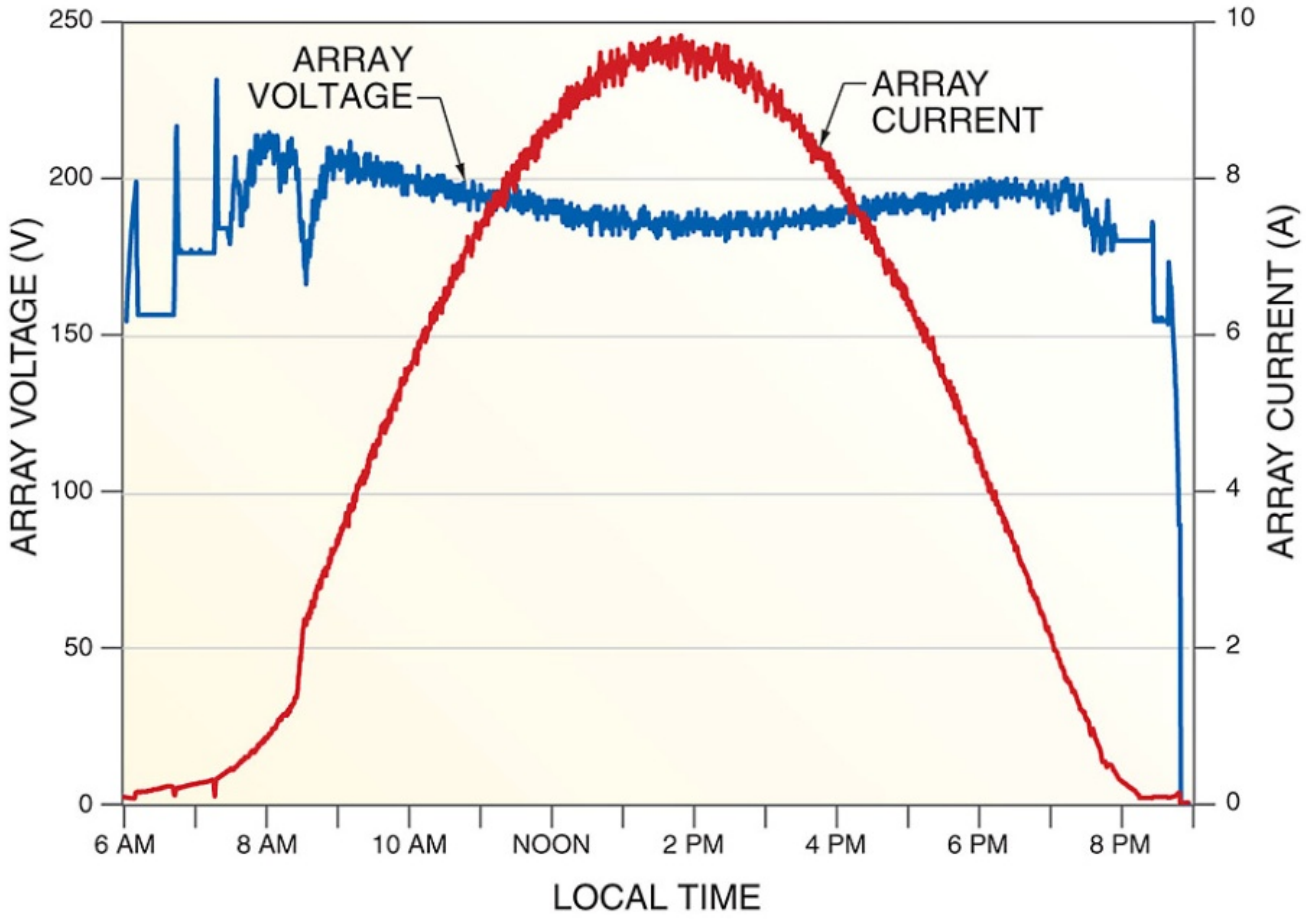
* maintenance plan tasks and recommended intervals will vary between systems

Primary Monitoring Points



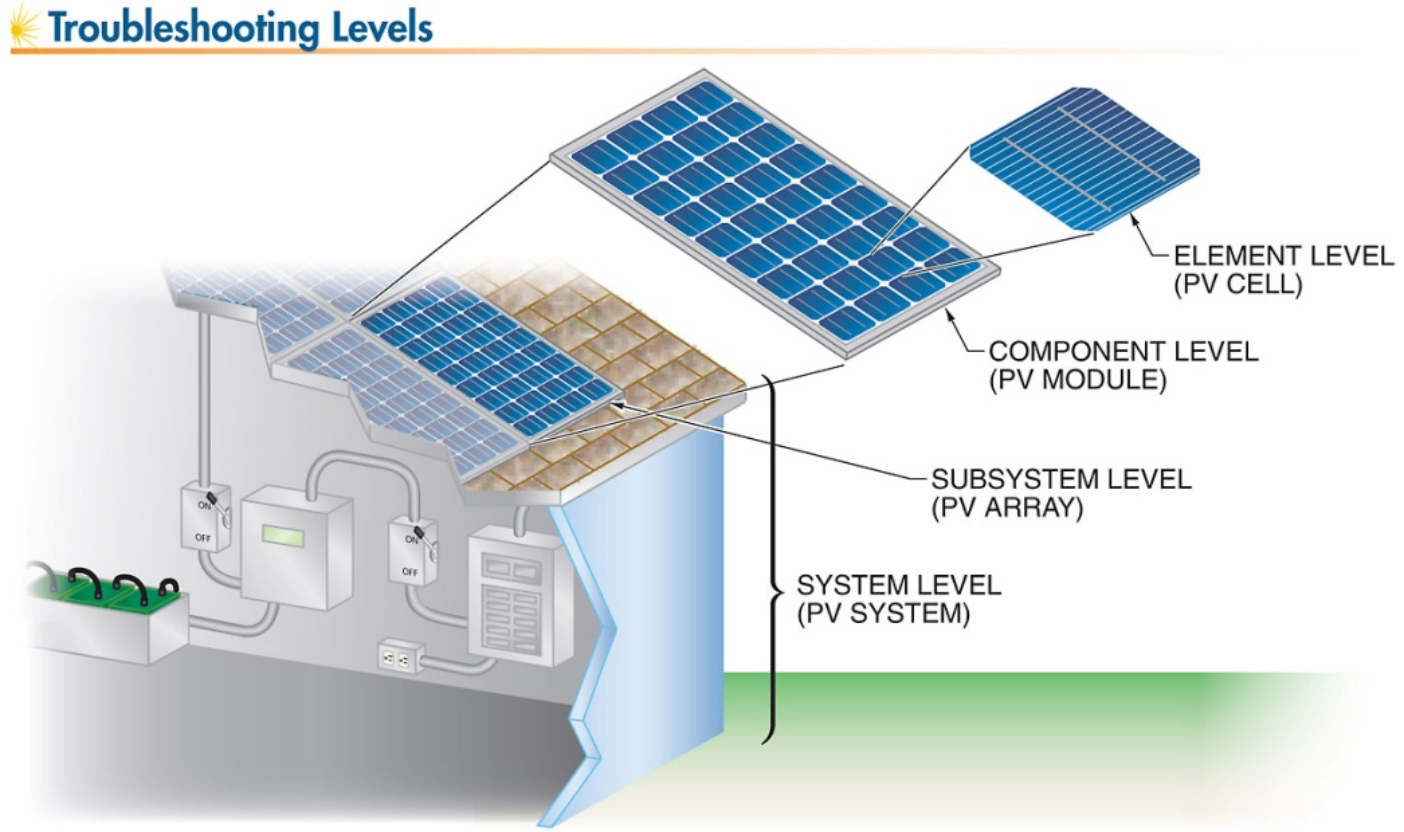
- The three most important points for measuring voltage and current information are the array output circuit, inverter output circuit, and battery-bank output circuit (if applicable).

Monitoring Data Plots

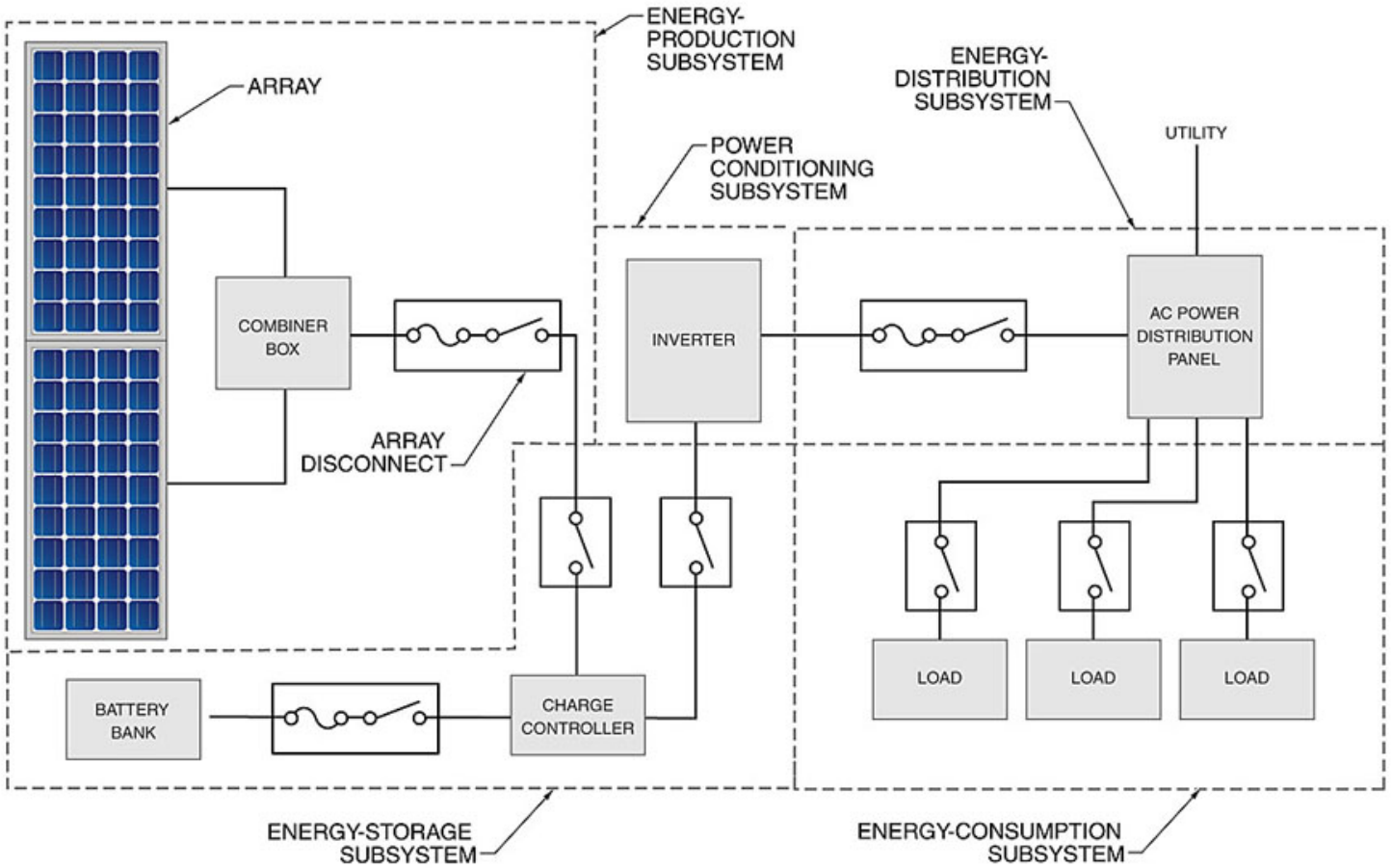


- Data-acquisition systems gather, record, and process information from many sources that can be used to observe trends or problems in PV system operation.

- The system level includes all the components of a PV system. If the system is interactive, the PV system overlaps with the utility system at the power-distribution equipment.

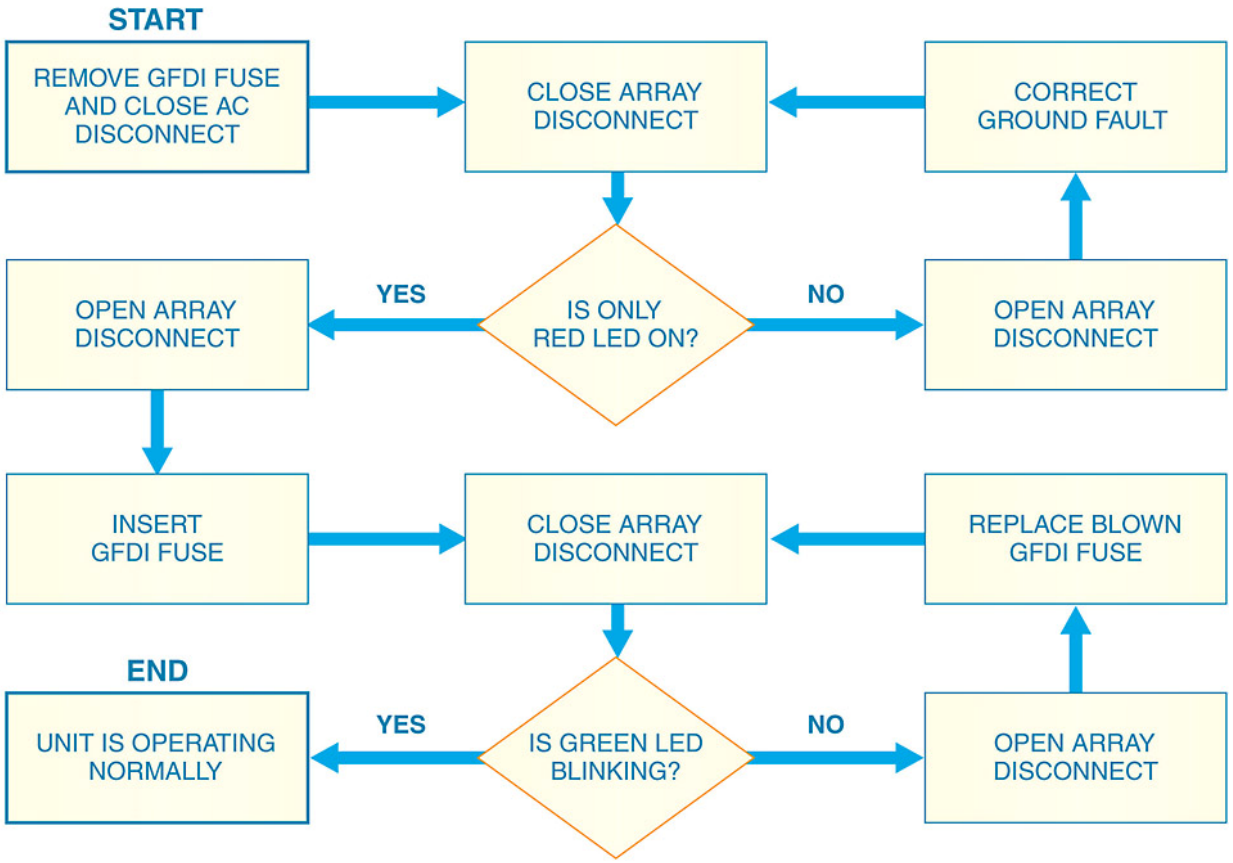


PV Subsystems



- PV subsystems are divided by the components involved in energy production, storage, processing or conditioning, distribution, and consumption.

Troubleshooting Flow Chart



- Some equipment manuals include troubleshooting flow charts, which narrow the possible causes of a problem by following a set of instructions.