GOSSEN METRAWATT

TESTING PHOTOVOLTAIC SYSTEMS AND EQUIPMENT

ELECTRICAL SAFETY
OF THE ENTIRE SYSTEM
AND PERFORMANCE DATA
FOR PV MODULES

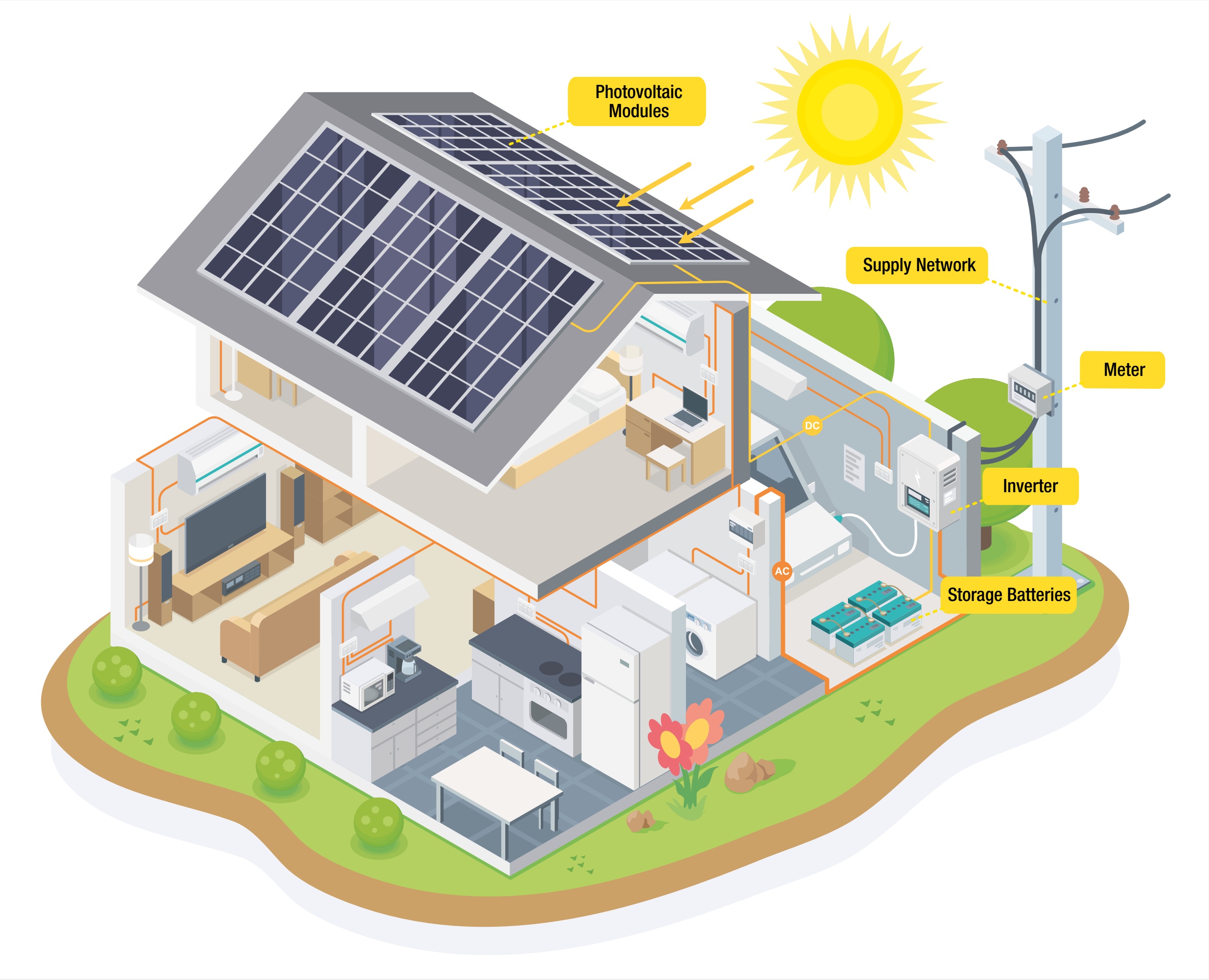
TESTING PHOTOVOLTAIC SYSTEMS AND EQUIPMENT

The field of photovoltaics has experienced rapid development since its beginnings in recent years. Insight and growing knowledge regarding the finite nature of fossil fuels and nuclear energy sources, as well as their consequences for the environment, have reawakened interest in solar technology.

Studies reveal that current use of photovoltaics is only the beginning of much more widespread, continuous growth. The German renewable energies act (EEG) supports environmentally friendly, self-generated electrical power. In actual practice, uncertainty often prevails as to which normative requirements must be observed when installing and troubleshooting PV systems.

TESTING PV SYSTEMS

A photovoltaic system (PV system) is a solar power installation which makes use of solar cells to convert a portion of the sun's rays into electrical power. A largescale solar power system is called a solar power plant. The typical, direct means of energy conversion used by these systems is known as photovoltaics. PV systems are electrical installations and are thus subject to DIN VDE 0100 and DGUV regulation 3. PV systems are also work equipment in accordance with the German ordinance on industrial safety and health (BetrSichV). The electrotechnical components of a PV system are electrical operating equipment and must therefore be operated, maintained and tested in accordance with generally recognized codes of practice.



Solar System in Single Family House

PHOTOVOLTAIC MODULES

Photovoltaic modules, or PV modules for short, are the most important component of a photovoltaic system because they convert sunlight into usable electrical power. Each module consists of numerous interconnected solar cells, which are usually made of silicon.

The best known types are crystalline modules and thin-film modules. Crystalline modules are especially popular because thin-film modules are significantly less efficient.

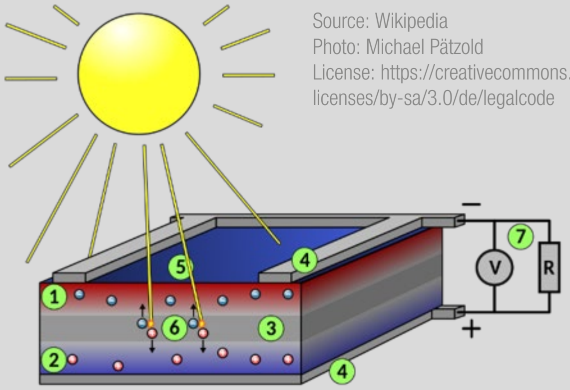
1) The upper silicon layer is negatively doped (n-layer).

2) The bottom silicon layer is positively doped (p-layer).

3) Excess electrons bind loosely to vacancies in the boundary region (p-n junction).

4) A continuously active electric field is generated between the upper and lower contact surfaces.

5) Photons (light quanta, "sun rays") penetrate into the transition layer.



Source: Wikipedia
Photo: Michael Pätzold

6) Photons with sufficient amounts of energy transfer energy to the electrons in the neutral zone. This releases the respective electrons from their bond. The electrons drift upward and the vacancies drift downward. Voltage and usable current are generated as long as photons continuously generate free charge carriers.

7) The "electron" current flows through the "outer circuit" to the cell's lower contact surface.

Monocrystalline Solar Cells:
Monocrystalline solar cells are easily recognizable due to their dark blue to black color. This color results from the manufacturing process. With this type of solar cell, the silicon wafer is produced from just a single silicon crystal. A silicon wafer serves as the substrate for all types of solar cells.

Polycrystalline Solar Cells:
Polycrystalline solar cells are comprised of not just one silicon crystal, but rather several. Various blocks of crystals are produced and then lined up next to each other. The resultant cell is cheaper, but it's less efficient as well.

Thin-Film Modules:
Thin-film modules don't have a crystalline structure. Only a thin layer of silicon and other substances is applied during the production process. Thin-film modules are much less expensive and lighter, but they're less efficient as well.

CIGS Modules:
These are a special type of thin-film module. Copper indium gallium (di)selenide (CIGS) is used in the thin-film modules. This results in significantly increased efficiency, but also in much higher production costs.

		Monocrystalline		Polycrystalline		Thin-Film		CIGS
Advantages	+	Highly efficient (approx. 21%)	+	Moderately efficient (approx. 16%)	+	Lightweight	+	Moderately efficient (approx. 17%)
	+	Minimal surface area	+	Low production costs	+	Low production costs	+	Lightweight
Disadvantages	-	High production costs	-	Moderate surface area	-	Minimal efficiency (approx. 7%) and large surface area	-	High production costs

TESTING PV SYSTEMS

Solar systems are technical installations with a certain degree of complexity and are often installed in difficult-to-access areas (roofs on houses and industrial facilities, remote outdoor sites etc.). They have to function reliably and be dependably safeguarded against accident hazards for persons.

Regulation DGUV V3, stipulated by German public accident insurance for the testing of electrical systems for the purpose of accident prevention, and technical rule TRBS 1201 regarding operational safety for the testing and inspection of work equipment and systems requiring monitoring constitute the basis for the testing of solar systems.

Valid test intervals and test criteria for entire systems are summarized in VDE standards VDE 0105-100, VDE 0100-600 and VDE 0126-23 of the Association of German Electrical Engineers. All solar systems must be fully tested every four years in accordance with these criteria.

System Inspected – Affix Inspection Seal

The following steps are completed during inspection of a solar system:

- Visual inspection of the equipment for damage and defects on insulation and cable harnesses
- Thorough functions test including the inverter
- Detailed comparison of the existing system configuration with documented data:
  If structural changes have been made to the system, they have to be listed in a verifiable manner.
- Thorough metrological inspection: Insulation resistance, open-circuit voltage, short-circuit current, total system power, low-impedance connections and protective equipotential bonding, which is particularly important for safety reasons, are measured.
- Testing the effectiveness of protective measures for the system constitutes a separate inspection step: Even a small photovoltaic system generates powerful direct currents in the cable connections and couplings, contact with which can be life-threatening.
- As a final step, the system is subjected to thorough functions testing: Are measured values consistent with momentary solar irradiance? Is the inverter functioning properly? Is the bidirectional remote control connection to the direct marketer functional, which is mandatory for larger plants? Are supply data provided and are control station switching pulses implemented?

PROFITEST PV SUN (characteristic curve tracing) und PROFITEST PV 1500 Test Instruments for PV Systems

TESTING PV SYSTEMS

Startup

The party responsible for setting up the PV system must write a report for each start-up procedure. Important report content includes measured values and system data.

Documenting the measured values:

- Insulation resistance on the DC side
- Earth resistance of the system
- Open-circuit voltage of the generator
- Open-circuit voltage of the string
- Short-circuit current of the string
- Voltage drop via diode and fuse for systems with string diodes/fuses (generator terminal boxes)
- Optional measurement of the characteristic curves of the individual strings
- Preparation of thermograms for the PV generator, as well as switchgear and fusing

Source: testo AG

Junction Box Thermogram

Requirements for System Documentation per VDE 0126-23-1 / IEC 62446-1

After installation or periodic testing of grid-connected PV systems, documentation with basic system data must be prepared for the customer, the inspector or the maintenance engineers.

Basic system data:

- Rated system power (kW DC or kVA AC)
- PV modules and inverter (model, manufacturer and quantity)
- Date of installation and initial start-up
- Customer name
- Address of installation location

Information concerning the system developer:

- Company name, contact person, address, phone number and e-mail address

Information concerning the system installer:

- Company name, contact person, address, phone number and e-mail address

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