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# Selecting Wire and Cable for Solar Applications

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**Introduction to Solar Power**

On a bright, sunny day, the sun's rays give off approximately 1000 watts of energy per square meter of the Earth's surface. This solar power can be converted into electricity in two basic ways: (1) the sunlight can be converted directly using photovoltaics (PV) or (2) it can be converted indirectly using concentrating solar power (CSP).

Photovoltaic refers to the direct generation of electricity by solar irradiation. Photovoltaic cells use special semiconductor materials, the most common being silicon, to harness solar energy. When light strikes the cell, some of the solar irradiation is absorbed within the semiconductor material. The energy of the light is now transferred to the semiconductor, knocking electrons loose and allowing them to flow freely and release energy.

CSP technologies use mirrors to reflect and concentrate sunlight onto receivers that then collect the solar energy before converting it to heat. The resulting thermal energy is then used to produce electricity through a steam turbine or heat engine that drives a generator.

Currently, three common types of CSP technologies exist: a parabolic trough, a solar power tower, and a solar engine. A parabolic trough is shaped like a half-pipe and is covered with mirrors that are aligned north-south and pivot to follow the sun during daylight. These mirrors concentrate the sun's rays onto heat transfer fluid pipes at 30 to 100 times their normal intensity. The pipes are then used to produce steam to spin a turbine to power a generator. Solar power towers, on the other hand, generally use thousands of flat sun tracking mirrors called "heliostats" to concentrate the sun's radiation onto a single tower-mounted receiver, at which point same process as the parabolic trough is applied. The last type of aforementioned CSP technologies is the solar engine, which contains both a solar concentrator and a power conversion unit. The most popular example of a solar engine is the Stirling engine, which uses a sun-tracking mirrored parabolic dish to direct captured heat to a hydrogen gas-filled piston. The piston then drives the engine to produce electricity. Over a twenty-year period, a Stirling engine system can generate over 850 MW of electricity.

Although the sun is an excellent energy source during the day, the method in which solar energy is stored is critical due to the lack of continuous supply. An effective and low-cost way of storing solar power is employing the use of molten salts. Salts have a high specific heat capacity and can deliver heat at temperatures compatible with conventional power systems. Off-grid PV systems traditionally store excess energy with rechargeable batteries. With grid-tied systems, the excess electricity can be sent to the transmission grid and kept track of using net metering programs. Net metering programs give such systems a credit for each megawatt of electricity delivered to the grid. These credits offset electricity provided from the grid when the system cannot meet demand, effectively using the grid as a storage mechanism.

**Cable Requirements**

Despite being a critical component, wiring for solar panels is rarely discussed. In home solar power

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systems, there are four components to connect together: the solar panels, the charge controller, the batteries, and the inverter. The charge controller is used to prevent the batteries from overloading; the wires that connect the panel to the charge controlled should be correctly sized to minimize transmission power loss. Correspondingly, the further away the panels are, the larger the wire gauge should be. The inverter is used to convert the DC power collected by the panels into AC power, which is the most popular form of electricity accepted by appliances. These systems are typically outdoors, so any cable used for this type of application needs to be ultraviolet radiation resistant and suitable for wet locations. For solar tracking panels, the cables used need to be flexible as the panels will be moving along with the sun.

CSP systems have a lot of requirements similar to solar panel. However, in addition to the water and UV resistance, the cables used need to be able to withstand high temperatures.

**Standards for Solar Power Cable**

Both the United States-based agency Underwriters Laboratory (UL) and the German-based agency Technischer Überwachungs-Verein (TÜV) have approvals specifically for wires used in photovoltaic applications.

UL has two types of approvals for photovoltaic applications: USE-2 and type PV. Originally, the standard approval for photovoltaic applications was USE-2. However, once there was a greater demand for wire for solar power, UL designed the UL type PV approval to meet the needs of such applications better. USE-2 and type PV approvals are similar; however, there are a few differences. PV wire can be used in both grounded and ungrounded PV arrays and is rated +90°C wet and +150°C dry with approvals for 600 V, 1000 V, and 2000 V. Although USE-2 is only suitable for grounded PV arrays per NEC, it has a +90°C wet and dry rating and is only rated for 600 V. In addition to the better temperature and voltage range, type PV wires have better sunlight resistance, low-temperature flexibility, flame resistance, and thicker insulations for additional element protection.

TÜV's Pfg 1169 approval is based on ISO 4892, EN50395, and EN50396 standards and tested according to IEC 60811 standards. The TÜV-approved wire is also generally low smoke, zero halogen, making it more environmentally-friendly. This approval is written specifically for the European market and is the preferred approval for manufacturers of solar panels.