Cables and Wires

For the components of a PV system (meaning the array, batteries, charge controller, and inverter) to work together and produce energy, something needs to join them together — enter wiring. The conductors used to connect all the individual pieces of equipment in a PV system are known as Wires. The PV side of the system has positive and negative conductors, and each one is connected to its respective part of the PV modules. The most common material for the Wires used in PV systems is copper because it has high conductivity (the ability to pass current) and is compatible with the Wire terminations (the place where the Wires are attached to the disconnects, circuit breakers, inverters, and charge controllers). Less expensive aluminium Wires can be an option, but aluminium is often viewed as an inferior wiring method. If you choose to use aluminium, the Wires generally need to be larger because aluminium doesn't possess the same conductivity as copper, and all the Wire terminations in a PV system would require explicit aluminium ratings. The terminations portion of the requirement can be the most difficult part to meet. If aluminium Wires (or copper Wires, for that matter) are connected to terminals that aren't rated for that material, the connections can eventually fail, increasing the risk of fire.

Sizing of System Cables

After sizing and selecting the major components, the interconnections wires are next. Selection of appropriate wire size and type enhances the reliability and performance of the photovoltaic system. The size of the wire must be capable of carrying the current at the operating temperature without excessive losses.

Type of wiring involve in PV systems:

PV wire

A double-insulated conductor known as *PV wire* uses cross-linked polyethylene for the insulation*.* This durable conductor was born out of the need for a conductor that could be used with a transformer-less inverter because the *IEC* requires additional protection in the form of conduit or multiple layers of insulation for the conductors on the PV side of these inverters. The two layers of insulation in PV wire help protect the copper conductors more than the single-insulated conductor.

PV wire is usually used inside PV source circuit wirings, but you can also use it as PV output circuit wiring. However, because it's more expensive than building wiring, most PV pros don't opt for this application.

Building wiring

Conductors that leave the junction box or combiner box on their way to the inverter or charge controller are usually transitioned into a standard type of building wiring, such as heat-resistant thermoplastic or moisture and heat-resistant thermoplastic . They can be aluminium or copper. Building wiring is usually used for PV output circuits, inverter input circuits, and inverter output circuits. You can use it on both the DC and AC sides of a PV system, but you need to make sure you protect the conductors from damage by running them inside conduit. Note that building wiring can't be run in exposed locations because it doesn't have the sunlight-resistant characteristics of and PV wire.

Battery wiring

the most widely available conductors for use from the battery bank to the inverter in battery-based systems are moisture-resistant thermoset, moisture- and heat-resistant thermoplastic (THW), and underground service entrance. All of these conductors are commonly made with copper.
Any conductors used for battery wiring are in corrosive environments, so you need to verify with the manufacturer and the *IEC* that the conductor type you want to use is appropriate for the location. *IEC* covers wiring methods and materials, so refer to the Code for more info.

Ground wiring

All the exposed metal parts of PV systems need a connection to ground, which means you need to connect the PV module frames, racking, and metal boxes to a conductor that's connected to a large conductor that's in contact with the earth. The conductors used to make the ground connections between PV modules are almost always bare copper. After the PV system's conductors are transitioned into conduit, either bare copper or insulated ground conductors can be used.

Color Coding for Cables and Wires for PV Systems:

The overall performance of PV systems also is strongly dependent on the correct choice of the cables. We therefore will discuss how to choose suitable cables. But we start our discussion with *color conventions*. PV systems usually contain DC and AC parts. For correctly installing a PV system, it is important to know the color conventions. For *DC cables*,

• **red** is used for connecting the +(positive) contacts of the different system components with each other while-

• **black** is used for interconnecting the –(negative) *contacts*. For *AC wiring*, different colour conventions are used around the world.

• For example, in the ***European Union***, **blue** is used for neutral,

green-yellow is used for the protective earth and **brown** (or another color) is used for the phase.
• In the ***United States*** **and** ***Canada***, **silver** is used for neutral, **green-yellow**, **green** or a **bare** Wire is used for the protective earth and **black** (or another color) is used for the *phase*.

• In India and Pakistan, **black** is used for *neutral*, **green** is used for the protective earth and **blue**, **red**, or **yellow** is used for the *phase*.
Therefore it is very important to check the standards of the country in that the PV system is going to be installed.

Color Coding for Cables and Wires according to *IEC:*

Function	label	Color, IEC	Color, old IEC
Protective earth	PE	green-yellow	green-yellow
Neutral	N	blue	blue
Line, single phase	L	brown	brown or black
Line, 3-phase	L1	brown	brown or black
Line, 3-phase	L2	black	brown or black
Line, 3-phase	L3	grey	brown or black

Losses in Cables

The cables have to be chosen such that *resistive losses* are minimal.
The power loss at the cables is given as-

$$P_{loss} = I \cdot \Delta V_{loss},$$

where ΔVcable is the voltage drop across the cable,

$$P_{\text{loss}} = I^2 R_{\text{loss}}$$

Hence, as the current doubles, four times as much heat will be dissipated at the cables. It now is obvious why modern modules have connected all cells in series. The voltage loss is increased when a conductor is operated at a higher temperature because the resistance increases.