



Distributed Energy Resources Grid Impact - Solar - Part 1

An Online Continuing Education Course for Engineers

Course Number: E-3057

Credit: 3 Hours / 3 PDH / 3 CPD

Distributed Energy Resources Grid Impact - Solar – Part 1

Ahmed Mousa, M.S.E.E.



Agenda:

- Voltage & Current
- Generation
- Transmission
- Substation
- Transformers
- Distribution System
- Per-Unit System
- Transformer Voltage Control
- Capacitor Banks
- DERs' Grid Impact



This course highlights the impact of Distributed Energy Resources (DERs), mainly solar, on the distribution electric grid and on the transmission system under normal and emergency conditions, highlighting the difference between the impact during sunny and cloudy days. Before discussing the impact of DERs, we will briefly describe the electric system and key components that get impacted by DERs.

Background:

Currently, there are many people employed in the renewable field, directly or indirectly, whether promoting/selling DERs or finding ways to mitigate their impact on the electric system. There are financial impacts (usually negative) to the electric utilities as well, mainly for power plant owners; however, this course focuses on the technical impact, biggest of which is the voltage.

Voltage:

Voltage is the potential difference between two points, known as the electric potential difference or simply the pressure difference. For non-electrical engineers, voltage is comparable to the pressure applied to the water hose.



Applying more pressure will result in more water flow thru the hose and decreasing the applied pressure will decrease the water flow. Applying no pressure will result in no water flow. The desire is to have a steady/stable pressure.



Current:

Electric current can be compared to the water flow in the hose; the applied pressure controls the amount of (water) current flow. The hose's material and diameter will also impact the electric current flow; this can be compared to the resistance/impedance phenomenon:

$V = IR$:

- V is the voltage
- I is the current
- R is the resistance

Clearly, voltage is inversely proportional to the resistance.

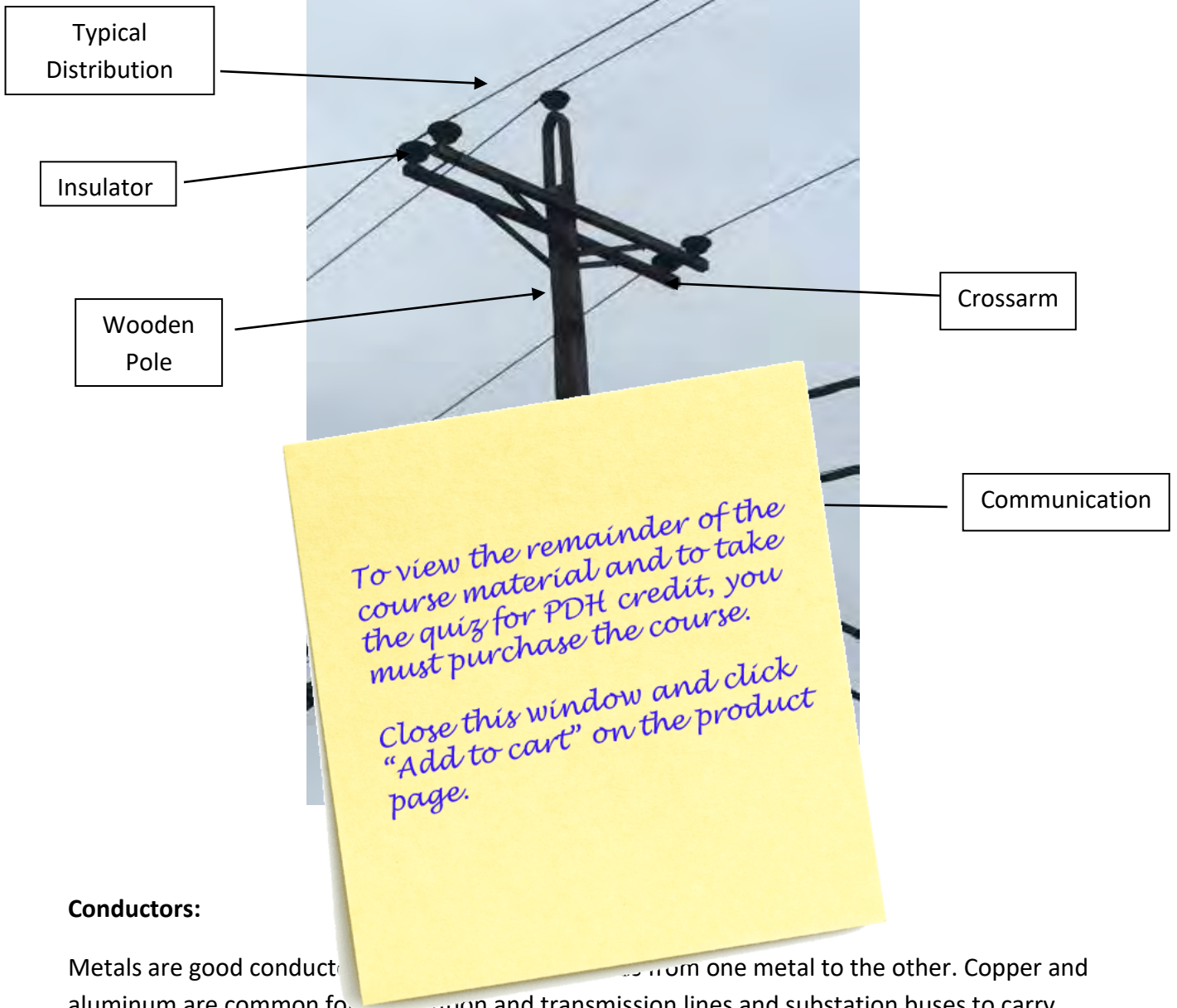
Most DERs are connected to the distribution system and not to the transmission system; the higher the interconnected voltage, the higher the required insulation, the larger the needed breakers, switchgear, equipment in general, thus the higher the cost. Having said that, based on the proposed DER size, it may be cost effective to connect to the transmission system.

We will not be discussing the characteristics of the distribution system in details in this course.

What is a typical distribution system?

Unless you live in a downtown area, where the distribution system is predominately underground (UG), the typical distribution system is overhead (OH). The picture below shows a typical distribution pole comprised of:

- Wooden pole
- Crossarm: carries the insulators and other equipment
- Insulator: holds the wires/conductors
- Communication cables.



Conductors:

Metals are good conductors and can be used from one metal to the other. Copper and aluminum are common for distribution and transmission lines and substation buses to carry electricity. Copper is a better conductor than Aluminum, but it is heavier and more expensive. We usually refer to OH conductor as wires/conductors and refer to UG wires as cables. The prior picture shows wires hanging on the insulators. It is clear from the picture that there are three wires on top of the pole, this represent one feeder and each wire represent a phase: A, B & C.

Insulators:

The opposite of conductors; insulators hold the wires in place so they don't fall and safely provide the needed isolation/insulation between the wires carrying electric current and the