Storage Batteries for PV System

Energy storage is very important at both small and large scales in order to tackle the intermittency of renewable energy sources. In the case of PV systems, the intermittency of the electricity generation is of two kinds: first, *diurnal* fluctuations, *i.e.* the difference of irradiance during the 24 hour period. Secondly, the *seasonal* fluctuations, *i.e.* the difference of irradiance between the summer and winter months. There are several technological options for realising storage of energy. Therefore it is important to make an optimal choice.

For short term to medium term storage, the most common storage technology of course is the *battery*. Batteries have both the right energy density and power density to meet the daily storage demand in small and medium-size PV systems. However, the seasonal storage problem at large scales is yet to be solved.

Battery parameters

Voltage:

First, we will discuss the *voltage* rating of the battery. The voltage at that the battery is rated is the *nominal voltage* at which the battery is supposed to operate. The so called *solar batteries* or lead acid grid plate batteries are usually rated at 12 V, 24 V or 48 V.

Capacity:

when talking about batteries, the term *capacity* refers to the amount of charge that the battery can deliver at the rated voltage. The capacity is directly proportional to the amount of electrode material in the battery. This explains why a small cell has a lower capacity than a large cell that is based on the same chemistry, even though the open circuit voltage across the cell will be the same for both the cells. Thus, the voltage of the cell is more chemistry based, while the capacity is more based on the quantity of the active materials used.

C-rate:

A brand new battery with 10 Ah capacity theoretically can deliver 1 A current for 10 hours at room temperature. Of course, in practice this is seldom the case due to several factors. Therefore, the *C-rate* is used, which is a measure of the rate of discharge of the battery relative to its capacity. It is defined as the multiple of the current over the discharge current that the battery can sustain over one hour.

State of charge:

State of charge (SOC) is the equivalent of a fuel gauge for the battery pack in a battery electric vehicle (BEV), hybrid vehicle (HV), or plug-in hybrid electric vehicle (PHEV). The units of SOC are percentage points (0% = empty; 100% = full). An alternate form of the same measure is the **depth of discharge** (**DoD**), the inverse of SOC (100% = empty; 0% = full). SOC is normally used when discussing the current state of a battery in use.

Usually, SoC cannot be measured directly but it can be estimated from direct measurement variables in two ways: offline and online. In offline techniques, the battery desires to be charged and discharged in constant rate such as Coulomb-counting. This method gives precise estimation of battery SoC, but they are protracted, costly, and interrupt main battery performance

Depth of Discharge *(DoD)*:

Depth of Discharge is an important parameter. It is defined as the percentage of the battery capacity that has been discharged.

Cycle lifetime:

The *cycle lifetime* is a very important parameter. It is defined as the number of charging and discharging cycles after that the battery capacity drops below 80% of the nominal value. Usually, the cycle lifetime is specified by the battery manufacturer as an absolute number. However, stating the battery lifetime as a single number is a oversimplification because the different battery parameters discussed so far are not only related to each other but are also dependent on the temperature.

Battery efficiency:

For designing PV systems it is very importent to know the *efficiency* of the storage system. For storage systems, usually the *round-trip efficiency* is used, which is given as the ratio of total storage system input to the total storage system output,

$$\eta = \frac{E_{out}}{E_{in}} \times 100\%$$