Tutorial problems (23750) for "Solar Energy" lecture (23745), WS 2014/2015

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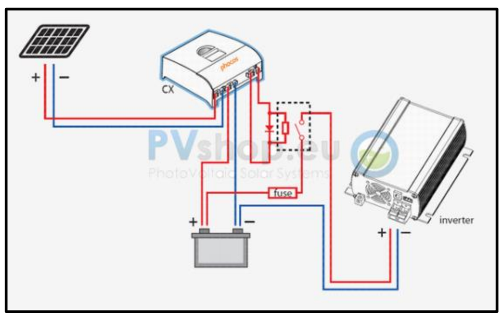
Tutorial Questions #6:

1. **Real System Design**

Let's think of a small house which is not connected to the main power grid (off-grid). The house should have the following electrical appliance usage:

- 1x18W lamp which is used 4 hours per day
- 1x60W fan used for 8 hours per day
- 1x75W TV that runs also 4 hours per day

Assume that all loads are operated after sunset. The electrical energy is provided by a solar panel, a 230V/50Hz inverter, a charge controller and a lead acid battery.



a) First of all, determine the demands of power consumption. How much is then needed from the PV modules?
b) Different size of PV modules will produce different amount of power. To find out the sizing of PV module, the total watt peak (Wp) produced needs. The peak watt (Wp) produced depends on size of the PV module and system location. We have to consider the peak sun hours (PSH) which is different in each site location. For central europe the factor is around 3, and corresponds to about 3 hours of sunlight, per day, expected average over the whole year (including in the winter time). Calculate the size of your PV module.
c) Size the inverter ($\eta = 90\%$) you will need. Assume a voltage of 12 V for the battery.

d) Size the battery capacity. The losses inside a lead acid battery are around 15%. The depth of discharge (DoD) should never be lower than 50%.

e) Size the charge controller ($\eta = 95\%$). Think of the short circuit current to prevent the charge controller from damage.

f) What changes in our system design if one of the loads (e.g. the fan) is operated during the day instead of at night time?

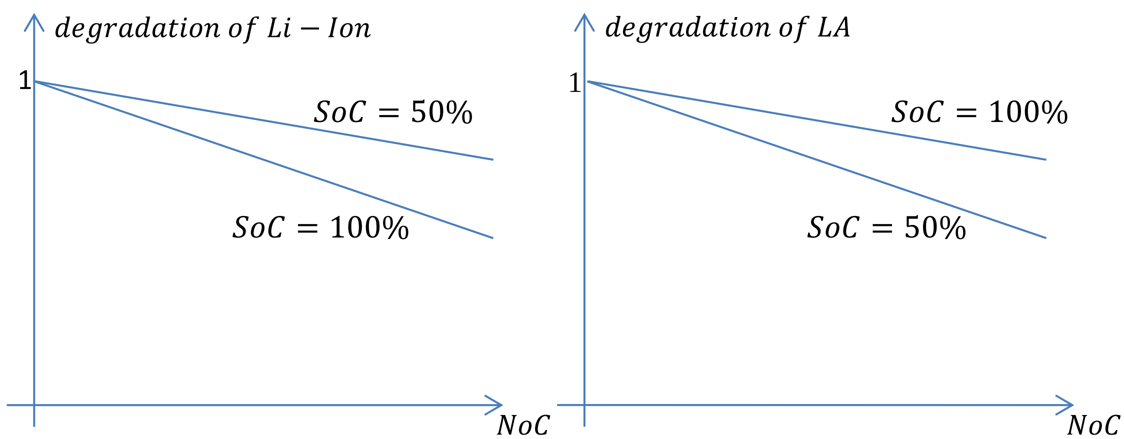
2. **Concept of a MPPT**

Imagine a standard solar cell I-V curve

a) Find a strategy (or condition) for the current and the voltage so that the power consumption is at a maximum.

3. **Li-Ion and LA Batteries**

Consider the following graphs for Li-Ion and LA batteries that compare the degradation (current capacity normalized to initial capacity) as a function of an average state of charge (SoC) and number of cycles (charge-discharge).



a) What is the best way to maximize the life of LA batteries.

b) What is the best way to maximize the life of Li-Ion batteries.

c) Outgoing from the graphs when is the best time for one of the battery technology in PV application?

d) What could be a reasonable combination of both batteries to maximize the overall life-time?