Exercise : A standalone photovoltaïc system design

Consider an installation consisting of:

- ✓ **1 television → 40W**
- ✓ **2 lamps → 20W each**
- ✓ **1 radio → 10W**

Time of equipment's' functioning:

- ✓ **television : 2.5h / day**
- ✓ **lamps : 3h / day**
- ✓ **radio : 1h / day**

1) Calculate the total energy consumed by all devices in one day.

The system is powered by photovoltaic solar panels.
The efficiency of **MPPT + DC/DC converter** is **75 %**. The efficiency of **the battery pack with regulator** is **70%.**
The efficiency of **DC/AC converter** is **95%**.

2) Calculate the total energy consumed at the entrance of DC / AC converter **(DC side).**

3) Calculate the minimal capacity (in Ah) of the battery to install for a **voltage of 48 V** if we want an autonomy of 3 days without sun.

4) Calculate the **new minimum capacity** if we want that the battery does not discharge **more than 50%** during the 3 days of autonomy (to preserve its life).

5) **Calculate the daily energy production** required to charge the battery to its maximum and to supply the receiving facility.

6) We consider an equivalent exposure time of **0.6 h at 1000 W/m²**, **Calculate the peak power** of the PV generator needed to provide the total required energy.

Correction:

1) $E(Wh) = Pabsorbed(W) \times time\ of\ functioning\ (h)$

Numeric application:

- television → 40 x 2.5 = **100 Wh**
- lamps → 2 x 20 x 3 = **120 Wh**
- radio → 10 x 1 = **10 Wh**

So a total energy consumed per day: 100 + 120 + 10 = **230 Wh**

2) The efficiency of DC/AC converter is 95%. The total energy consumed at the entrance of the DC / AC converter **(DC side)** is then: $\frac{\boldsymbol{Consumption\ DC\ side}}{\boldsymbol{Efficiency}} = \frac{\mathbf{240}}{\mathbf{0.95}} = \mathbf{242\ Wh}$

3) We want **an autonomy of 3 days.** Therefore, we must be able to provide **3 times** the energy daily consumed at the entry of DC/AC converter, i.e.: $\mathbf{3 \times 242 = 726\ Wh}$
Considering the battery **efficiency**, it is necessary to store: $\frac{\mathbf{726}}{\mathbf{0.7}} = \mathbf{1037\ Wh}$
The capacity of the battery is therefore: $\frac{\mathbf{1037}}{\mathbf{48}} = \mathbf{22}\ \boldsymbol{Ah}$

4) If you do not want that the battery discharges more than 50% when you have 3 days without sun, **you must store two times more energy:** $\mathbf{2 \times 22}\ \boldsymbol{Ah} = \mathbf{44}\ \boldsymbol{Ah}$

5) To charge the battery to its maximum SOC and to supply the receivers, **photovoltaic panels must produce:** $\boldsymbol{E_{to\_prod}} = \frac{\mathbf{242+44\times48}}{\mathbf{0.75}} = \mathbf{3138.7}\ \boldsymbol{Wh/day}$

6) **In an equivalent exposure time of 0.6 h at 1000 W / m²**, to produce 3138.7Wh, we need a peak power of:

$$\boldsymbol{P_c} = \frac{\boldsymbol{Energy\ to\ product}}{\boldsymbol{N_{e\ \ at\ 1000Wh/m^2}}} = \frac{\mathbf{3138.7}}{\mathbf{0.6}} \approx \mathbf{5232}\boldsymbol{W_c}$$