

1 ENERGY STORAGE

- 1.1 A water well is in a location with a mean daily solar radiation of 4.8 hours of sun. The PV powered pump is able to produce 16m³ /day from a depth of 18m.
- Determine the required capacity of the batteries for autonomy of 3 days.
 - Determine the required installed PV power.
- 1.2 How much water would have to be pumped to a tank raised 3 meters from the ground in order to be able to recover 1kWh of electricity? [Assume 100% conversion efficiency.]

2 MODULE TEMPERATURE

- 2.1 A module datasheet states the following module parameters: $I_{sc} = 3A$; $V_{oc} = 20.4V$; $P_{max} = 45.9W$; $NOCT = 43^{\circ}C$. Determine the parameters (I_{sc} , V_{oc} , FF , P_{max}) of a module formed by 34 solar cells under the following operating conditions: $G = 700W/m^2$; $T_a = 34^{\circ}C$.
- 2.2 A PV module is found to operate at 60°C when $T_a = 30^{\circ}C$ and $G = 980W/m^2$. Determine the NOCT of the module.
- 2.3 Determine the variation with ambient temperature (between -25°C and +75°C) of the power of a module (under standard 1000W/m²) with 36 Si cells in series each with $I_m = 5.85A$ and $V_m = 0.5V$ at 25°C and a $NOCT=45^{\circ}C$.

3 SIZING A GRID CONNECTED SYSTEM

Modules as those described in Table 1 are to be connected to an inverter with the specifications presented in Table 2. The modules' temperature range is -10 to 40°C.

Table 1: Module specification

Voc	30.2 V
Vm	24 V
Isc	8.54 A
Im	7.71 A
T coeff P	-0.485 %/°C
T coeff V	-0.104 V/°C

Table 2: Inverter specification

Max DC power	3200 W
Max DC voltage	600 V
MPP voltage range	268 - 480 V
DC nominal voltage	350 V
Min DC voltage	268 V
Max input DC current	12 A
Max output AC current	15 A

- Determine the module voltage range.
- Determine the minimum number of modules in a string, considering a 2% drop loss in the DC cables and a 10% safety margin for the minimum inverter input voltage.

- c) Determine the maximum number of modules in a string, considering a 5% safety margin for the maximum inverter input voltage.
- d) Determine the number of strings by matching the current specifications (neglecting temperature effects).
- e) Compare the array DC power of the configuration specified in the previous questions to the max DC power of the inverter.

4 HOMEWORK

Using PVSYST, design the optimal PV system for a high school with the following demand. The schedule for the different tariffs is as shown in <https://poupaenergia.pt/tarifas-e-ciclos-horarios/>

Month	Consumed energy (kWh)					Cost
	Ponta	Cheias	Vazio Normal	Super Vazio	Total (kWh)	
Jan	2,248	6,376	1,490	958	11072	2,110.63 €
Feb	3,254	9,310	1,509	936	15009	2,839.86 €
Mar	2,640	7,800	1,310	781	12531	2,365.47 €
Apr	2,556	7,261	1,444	890	12151	2,294.68 €
May	2,429	6,490	1,920	861	11700	2,179.12 €
Jun	2,678	6,459	1,520	907	11564	2,236.54 €
Jul	1,936	4,592	1,446	906	8880	1,702.40 €
Aug	928	2,226	1,008	714	4876	951.32 €
Sep	828	2,020	937	642	4427	871.58 €
Oct	2,556	7,761	1,444	890	12651	1,900.45 €
Nov	2,652	6,774	1,712	1,002	12140	2,328.46 €
Dec	2,696	9,358	1,572	982	14608	2,675.11 €
TOTAL					131609	24,455.62 €