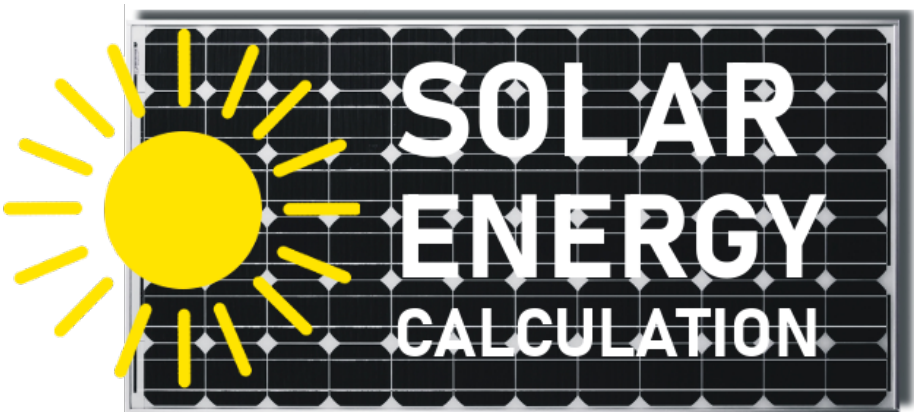


1 Specification

3

You have ordered a sizing of an off-grid solar power system in **Madrid** (lat. 40.27 long. -3.59), which should be able to supply the specified daily electrical energy to the devices listed below.

Device	Energy consumption [Wh]
Device 1	2000

Table 1: Specified desired power supply.

This system should be well-functioning during a period when **10** days of bad weather [4] occur, given that these days are followed by **1** days of average weather (with average solar irradiance).

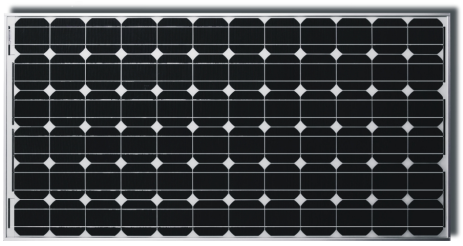
2 Conclusion

You need at least **2000 W** solar panels and **19.87 kWh** batteries in order to guarantee your supply of electricity when the **10** days of bad weather occur.

Necessary solar panel power

2000 W

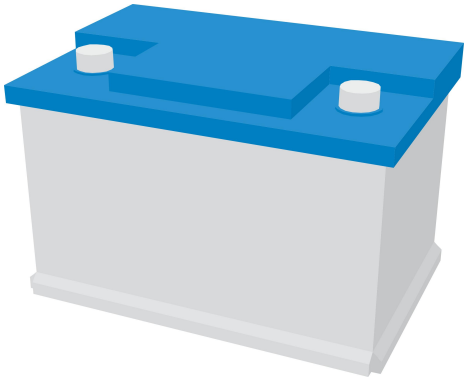
For example 10 solar panels with 200 W power.



Necessary battery energy

19.87 kWh

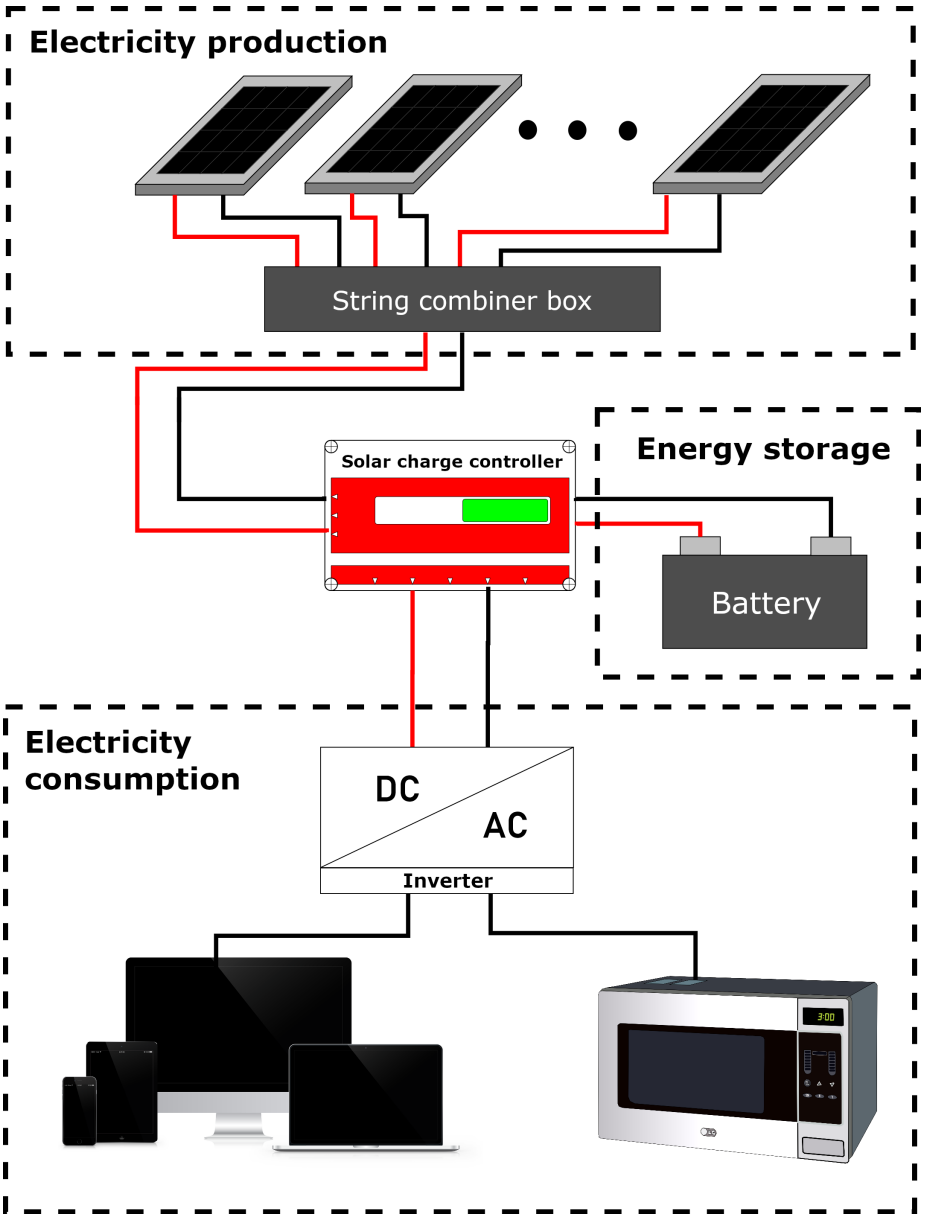
Corresponding to the battery capacity 1656Ah for 12 V lead acid batteries. This can for example be fixed by connecting 23 batteries with the capacity of 72 Ah in parallel.



Sunny off-grid

3 Your solar power system

In the block diagram below you can see a suggestion on how you can connect your solar power system together in order to supply your electronics with electricity.



4 Motivation

The number of solar panels and batteries have been calculated with the goal that the battery bank's state-of-charge should never fall below 50 % (it is important for lead acid batteries [1]), after a period when the weather is bad during 10 days in a row. Bad weather here is defined as that the sunlight's irradiance only reaches 10 % of the average irradiance for the given month.

In the graphs below you can see how your solar power system has been simulated for the months for which you have chosen that it should work well. In the column to the left you can see input data for your location, which is irradiance (the sunlight's power per square metre) [2] and the solar cell temperature [2]. In the column to the right you can see the resulting electric power and the state-of-charge level in your battery bank, as the number of solar panels stated under Conclusion have been used. In the simulation it has been assumed that the solar panels are aligned towards the south(azimuth angle), with the tilt angle of 32°, which is a suitable tilt angle for solar panels in your location [5]. It has also been assumed that monocrystalline solar panels are used, since these have higher efficiency compared with polycrystalline solar panels and therefore take up less space. [3].

May

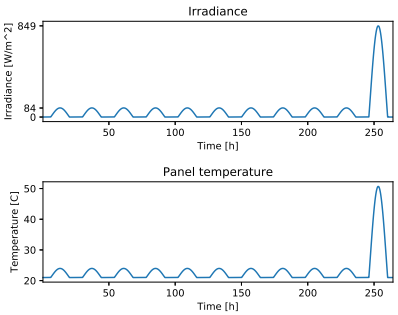


Figure 1: Solar irradiance and cell temperature for the solar panels during 11 days.

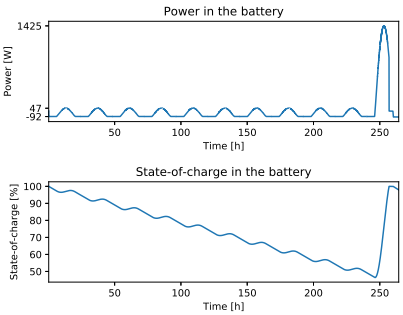


Figure 1: Power and state-of-charge level in the battery during the 11 days.

June

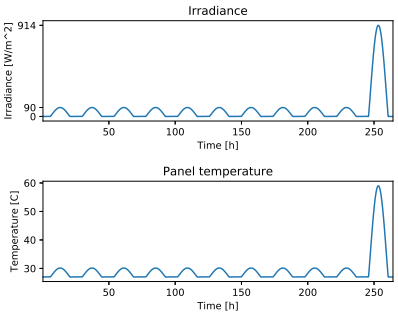


Figure 2: Solar irradiance and cell temperature for the solar panels during 11 days.

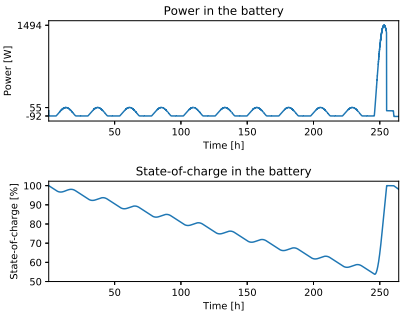


Figure 2: Power and state-of-charge level in the battery during the 11 days.

References

[1] *How To Size Your Off Grid Battery Bank Capacity For Solar - Math Warning!* LDSreliance. URL: https://www.youtube.com/watch?v=iGTTUzN5Jjs (visited on 03/24/2019).

[2] *Photovoltaic Geographical Information System.* JRC. URL: http://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#DR (visited on 03/24/2019).

[3] *Pros and Cons of Monocrystalline vs Polycrystalline solar panels.* solarreviews.com. URL: https://www.solarreviews.com/blog/pros-and-cons-of-monocrystalline-vs-polycrystalline-solar-panels (visited on 03/24/2019).

[4] *Solar Performance in Cloudy, Rainy and Sunny Conditions.* voltaicsystems.com. URL: https://www.voltaicsystems.com/blog/solar-performance-clouds-rain/ (visited on 05/06/2019).

[5] *World estimates of PV optimal tilt angles and ratios of sunlight incident upon tilted and tracked PV panels relative to horizontal panels.* Stanford University. URL: https://web.stanford.edu/group/efmh/jacobson/Articles/I/TiltAngles.pdf (visited on 02/02/2020).