

MANUAL SUN ENERGY LAB

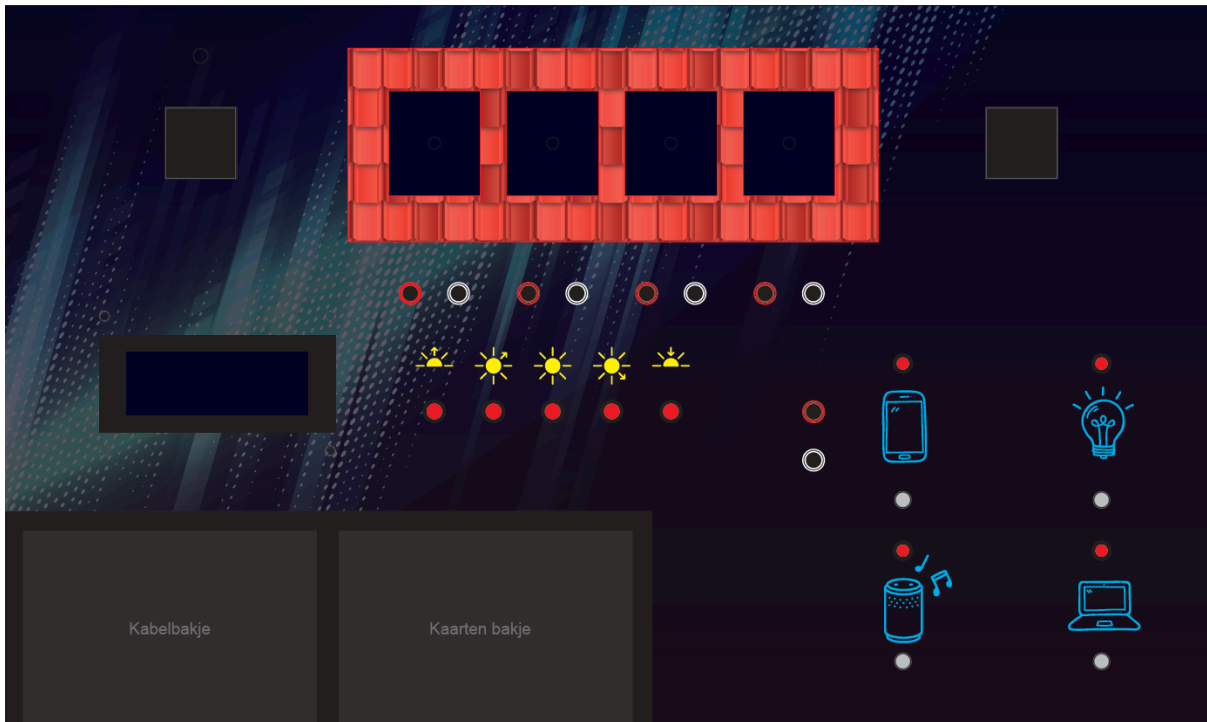
1. Solar energy for youngsters	1
2. Setup	2
3. Operation of the installation	3
4. Various options for connecting solar panels	4
4.1 Measurement on 1 solar panel	4
4.2 Measurement on 2 solar panels	5
a) Parallel connection	5
b) Series connection	6
4.3 Measurement on more than 2 solar panels	6
4.4 Combination of series- and parallel connection	6
5. Switching electrical loads	6
6. Circuit diagram	8
7. More information	9

1. Solar energy for youngsters

Sun Energy Lab introduces youngsters of various ages (12 - 18+) to the functioning of solar energy. They learn what to consider when installing a solar panel system and which factors play a role. The installation contains exercises at different levels, tailored to prior knowledge and age.

This educational kit was developed by Schokarts bv, commissioned and co-created by Het Beroepenhuis, as part of the Erasmus+ project Alpha Skills.

2. Setup



The front panel contains four separate switchable solar panels. Above the panels is an aluminum frame with three halogen spotlights, which can be set in different (solar) positions using five buttons.

Different configurations can be made with the solar panels and then connected to the loads at the bottom right: mobile phone charger, bluetooth speaker, lamp and laptop.

Each of the four loads can be switched on or off with its own selector switch. In order of consumption, the loads are: the mobile phone charger, the bluetooth speaker, the lamp and the laptop.

In total, 15 different combinations are possible.

The display shows the measurements of voltage, current and power supplied by the solar panels to the loads.

At the bottom left is the cable box with connection cables and exercise cards.

3. Operation of the installation

Components and functions:

- 1) **Solar panel:** this is a source of electricity, most easily compared to a battery. The source does not provide energy when it is dark. The energy that the source can supply, increases as the light falling on the panel becomes stronger, up to a maximum depending on the type of solar panel.

The efficiency of a solar panel is typically 10% to 20%, depending on the type of solar panel. A 1m² solar panel therefore provides 100 to 200 watts at an irradiation of 1000 W/m².

Irradiance of 1000W/m² is the irradiance we get on a very sunny day. Irradiance will usually be lower than 1000W/m². Only at noon on a sunny summer day can irradiance sometimes exceed 1000W/m².

In addition, the efficiency of a solar panel will also decrease as the temperature rises. On a very sunny day in winter, a solar panel can, in principle, generate a higher maximum power than in summer. However, over the course of a whole day, you will still have less power than in summer, as the days are much shorter in winter.

Solar panels can be connected in series or parallel, or a combination of these connections. This is only possible with identical panels.

- 2) **Electrical loads in the installations:** The loads in the installation are always a LED connected with an additional consumer resistor. The mobile phone charger is a LED with a 100 ohm resistor connected in series. Understanding how this works requires basic electronics and electrical knowledge..

- a. Load mobile phone charger = red LED with 100 ohm resistor in series connection.
- b. Load bluetooth speaker = red LED with 100 ohm resistor in a series connection. A 510 ohm resistor is connected in parallel across this series circuit.
- c. Load lamp = red LED with 100 ohm resistor in series connection. A 150 ohm resistor is connected in parallel across this series circuit.
- d. Load laptop = red LED with 100 ohm resistor in series connection. An 82 ohm resistor is connected in parallel across this series circuit.

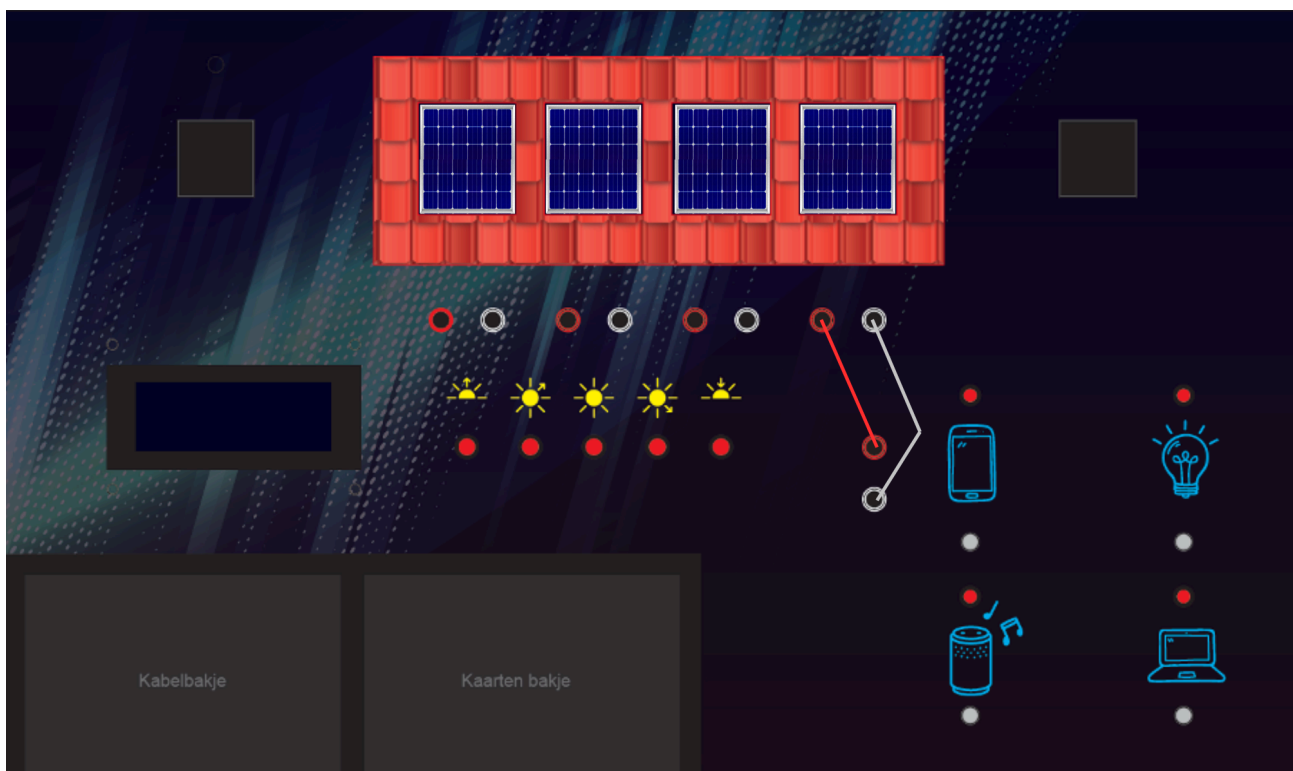
- 3) **The voltage measurement and the calculation of current and power are performed in the control module, the Arduino Uno.**

This control module also regulates the switching of the halogen spotlights. Use the switch next to the display to switch between the options “correct measurements” or “converted

measurement". The correct measurement is the measurement of voltage, current and power measured by the solar panels. The converted measurement provides a conversion to more understandable (higher) power measurements, which better correspond to a real solar panel installation on a house.

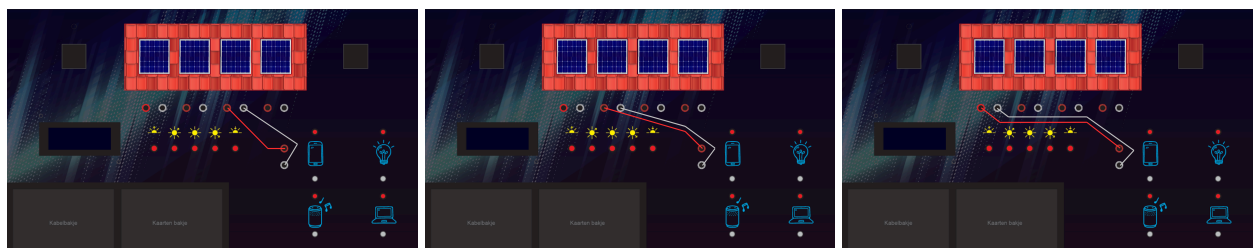
4. Various options for connecting solar panels

4.1 Measurement on 1 solar panel



The voltage of a single solar panel can be measured at different irradiation levels (solar positions via the buttons). The voltage is shown on the display.

This measurement can be performed separately for each panel and compared using the display.



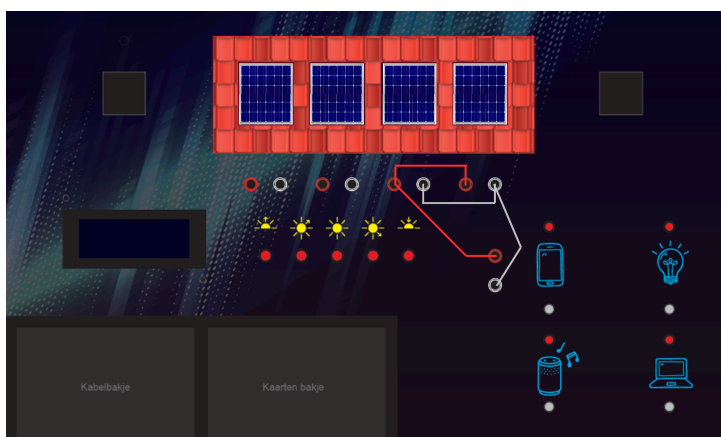
One or more loads can be switched on for each of the above connections.

How switching loads works is discussed in detail below.

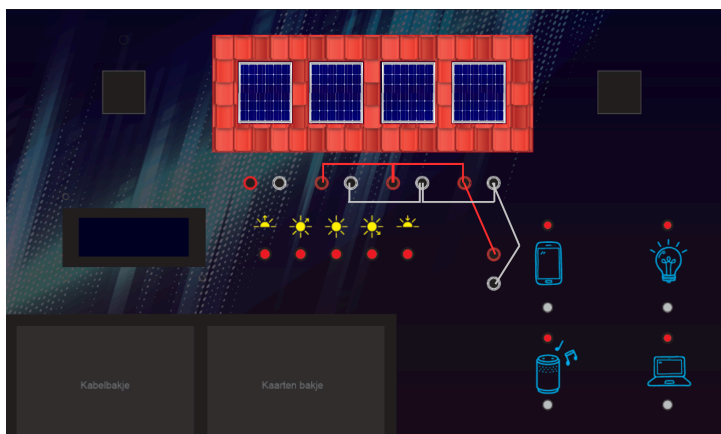
The voltage from a single panel is usually insufficient to power a lamp. However, current and power are shown on the display. A basic understanding of electricity is required to understand this.

4.2 Measurement on 2 solar panels

a) Parallel connection

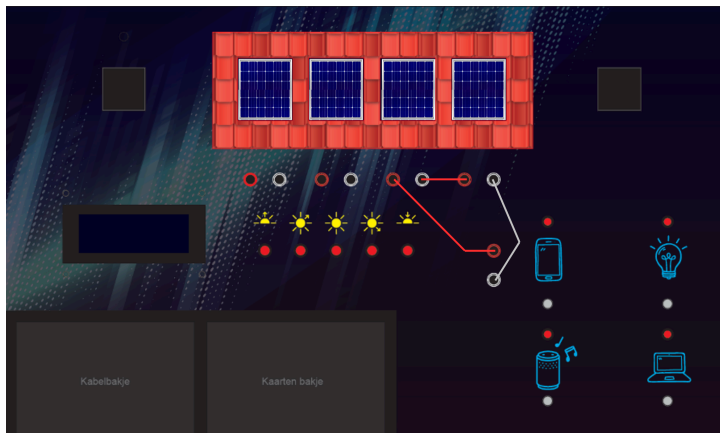


The voltage is measured again at different solar positions and different loads. Compare this with switching one solar panel.



The other solar panels can also be connected in parallel, or two different ones can be connected in parallel at a time. It is interesting to try to predict what will be measured and then check whether the prediction is correct.

b) Series connection

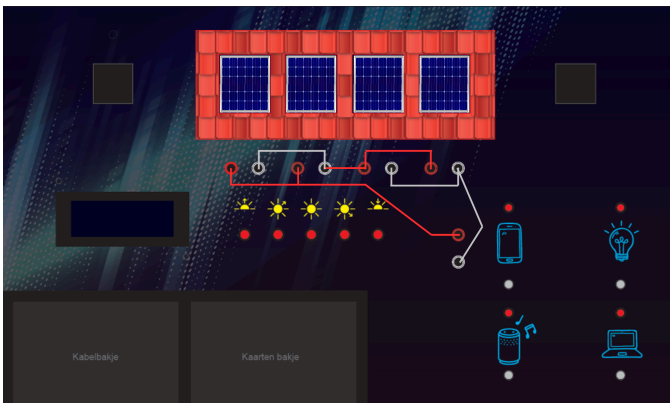


The measurements are performed in the same manner. If you connect two solar panels in series, you get the sum of the voltage of both panels; the measured voltage doubles.

4.3 Measurement on more than 2 solar panels

- Measurement on three or four solar panels in a series connection. The measured voltage is the sum of the voltage of the individual panels.
- Measurement on three or four solar panels in a parallel connection.
The voltage will remain the same, but the current from the individual panels will add up.

4.4 Combination of series- and parallel connection



The highest power is achieved with a combination of a series and a parallel connection. This depends on the irradiation, i.e. the position of the sun. This is the most complex connection.

5. Switching electrical loads

You can switch four loads on and off using the selector switches. This allows you to test a solar panel circuit under different loads. You can switch between 15 different configurations.

In order of consumption, you will find the mobile phone charger, the bluetooth speaker, the lamp and the laptop.

Load A = mobile phone charger (10 Watt).

Load B = bluetooth speaker (20 Watt).

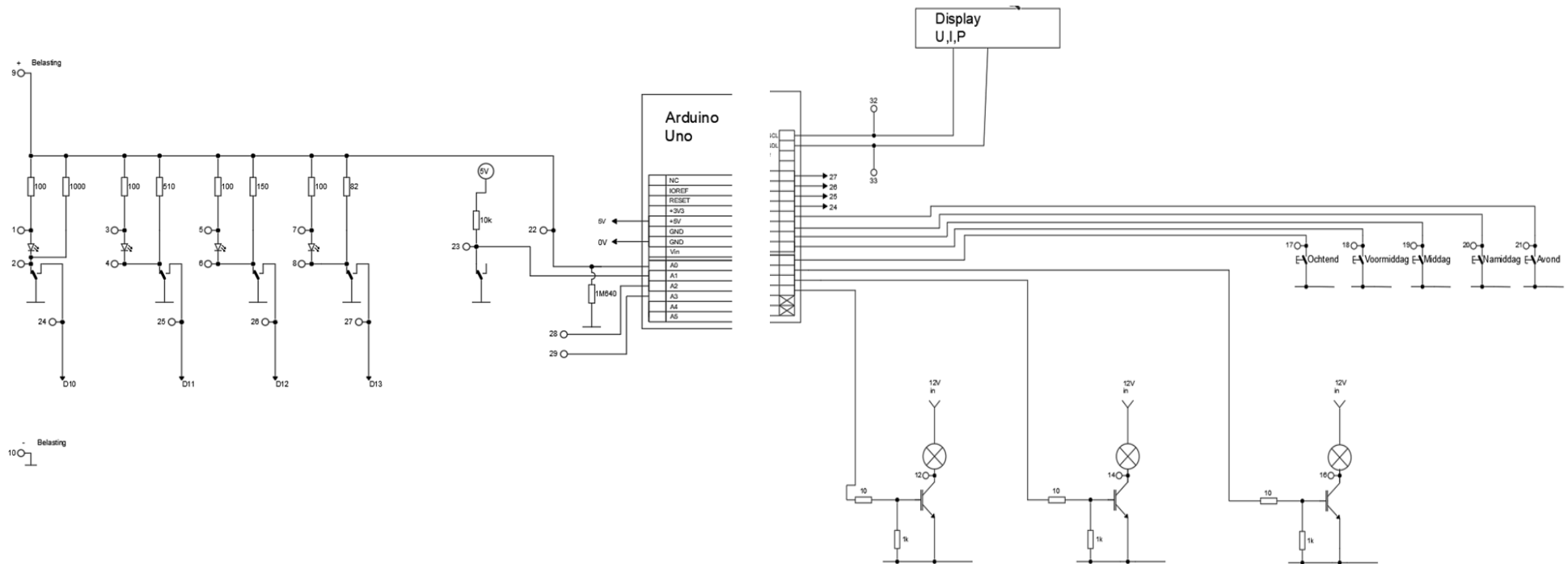
Load C = lamp (100 Watt).

Load D = laptop (200 Watt).

These are the different configurations:

- 1) Unloaded: no load is connected; you measure the maximum voltage that connected configuration of the solar panels can provide. The measured current = 0. The power = 0 as well. After all, the power P is the voltage (U) multiplied by the current (I), so $P = U \times I$, since $I = 0$ in this state, $P = U \times 0$ and therefore $P = 0$.
- 2) Mobile phone charger is switched on: this is the lightest load. If you do not have sufficient voltage, the red light will not turn on. No current is flowing and the power is still 0. With 2 or more solar panels in a series connection, the red light will turn on and current and power will appear on the display.
- 3) The mobile phone charger is switched off and the bluetooth speaker is switched on.
- 4) The mobile phone charger and the bluetooth speaker are both switched on.
- 5) The mobile phone charger and the bluetooth speaker are both switched off and the lamp is switched on.
- 6) The lamp remains switched on and the mobile phone charger is turned on.
- 7) The lamp remains switched on, the mobile phone charger is switched off and the bluetooth speaker is switched on.
- 8) The lamp, mobile phone charger and bluetooth speaker are switched on.
- 9) Everything is switched off and the laptop is switched on.
- 10) The laptop remains switched on and the mobile phone charger is turned on.
- 11) The laptop remains switched on, the mobile phone charger is turned off and the bluetooth speaker is turned on.
- 12) The laptop + mobile phone charger + bluetooth speaker are turned on.
- 13) The laptop and lamp are switched on, the other loads are switched off.
- 14) The laptop + lamp + mobile phone charger are switched on.
- 15) All loads are switched on.

6. Circuit diagram



7. More information

Want to know more about the technology of the Sun Energy Lab? Contact Schokarts bv.

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Want to know more about the activity cards that are part of Sun Energy Lab?

- Visit <https://www.alphafutureskills.eu/>
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