STEAM4Climate Teacher’s Guide
to Project-Based Climate Education

Project: Sustainable housing

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Introduction

UN Sustainable Development Goals

1. Learning Overview

In this project, students will be introduced to sustainable housing design strategies by creating a paper model of a building (such as their school building) and embedding a solar panel that harvests solar energy and channels it to various building operations, making the building more efficient in terms of energy consumption, minimizing its carbon footprint. This interdisciplinary and hands-on project combines elements of electrical circuit design, engineering, and crafting, allowing students to explore key STEAM concepts in a fun and practical way.

Key Concept:

Duration: 8 hours (more time can be allocated to expanding the project idea, experimenting with different materials or design strategies e.g. embedding a wind turbine to harness wind energy)

Number of Sessions: 2 or 3

Target Age Group: secondary school, 12+

2. Learning Objectives

This project provides a comprehensive learning experience that integrates creativity with technical skills, providing students with a holistic approach to understanding the concept of sustainable housing in terms of design strategies and the use of renewable energy sources. In particular, students will be able:

- To explain what a sustainable building is
- To identify some design strategies to create a sustainable building
- To explain what a solar panel is
- To explain why solar store is important and how it can be achieved
- To experiment with various electrical circuit configurations and solutions
- To explain how solar energy turns into electricity
- To create a paper model and embed solar panel in an efficient way
- To identify parameters that affect the performance and efficiency of solar panels (e.g., location, orientation, pollution, shading etc.)
- To recognize and explain the function of different electrical components within a circuit
- To use simple programming commands to control how the stored solar energy is channeled into various operations of the building
- To reflect on the broader implications of sustainable building and its impact on mitigating climate change.
- To build teamwork skills during design, construction and troubleshooting processes

3. Methodology

Teachers are encouraged to blend hands-on practice with reflective tasks, guiding students through:

- **Hands-on experimentation:** bringing together electrical circuit making, programming and artefact construction using everyday tools and objects. Students actively engage in building circuits, embedding solar panels into their paper models, and exploring how solar energy is captured, stored, and utilized. Everyday materials and simple electronic components can be used to construct functional prototypes that bring theoretical ideas to life.
- **Reflective tasks:** A number of reflective questions are proposed to trigger students' engagement on the project and challenge them to think different aspects related to solar power and broader environmental topics. For example: "What makes a building sustainable?", "How does solar energy become electricity?", or "What factors influence solar panel efficiency?".
- **PBL Self-science:** The project can inspire engagement in new educational initiatives that are real, relevant and meaningful to students. They may further act as "explorers" of real-world problems (e.g., reducing a school's carbon footprint) and propose solutions.

A "Low Floor, High Ceiling, Wide Walls" Approach

In STEAM4Climate, we adapted an approach that empowers students to explore scientific concepts related to climate change through constructions and use of a variety of physical and digital tools to solve problems, understand phenomena, express their creativity, boost confidence as problem solvers and communicator of ideas and positive messages.

Low Floor: Every student can participate, even with minimal prior knowledge. They can begin by building a simple paper model of a building and connecting a small solar panel to light an LED, using basic materials and simple electronic structures. To further make this entry point accessible ready-made mockups are also available for students to assemble.

High Ceiling: As students grow in confidence and curiosity, they can extend the project in more complex and ambitious directions. They may explore how solar energy can power different building operations, experiment with circuit configurations, integrate simple programming for automation, or analyze how environmental factors (e.g., orientation, shading, pollution) affect performance. They can even embed sensors or microcontrollers to collect and interpret data.

Wide Walls: The project invites a variety of creative and interdisciplinary pathways. Students can personalize their building models, design structures inspired by real-world sustainable architecture, or combine solar power with other renewable solutions such as small wind turbines. They can also compare different renewable energy sources, broadening their understanding of how technology and design can support sustainability.

Whether indoors or in the field, every learner's path is different, and each solar-powered house has the potential to become more than just a model. It becomes a story of curiosity, effort, and environmental awareness.

Materials

4. Materials Included in Toolbox for basic version

- Solar Panel
- Solar store
- LED light
- DC motor
- Alligator clips
- BBC micro:bit board

- USB to micro-USB cable
- AAA battery holder – Optional

Please find a detailed description of the basic electrical components needed for this project in the Appendix - Description of basic electrical components

5. Other components for basic version

Materials for crafting may include cardboards, glue, balsa wood, popsicles, scissors, silicon pistols and more.

Important note: This project comes with ready-made mock ups[1] of the solar-powered house model that needs to be assembled.

6. Components for extended version

According to "high ceiling" and "wide walls" approach, there are many options to expand project or go deeper into a specific field. Some examples include:

- 3D Printer: For printing custom parts of the house or bases of solar panels
- Filament: PLA or PETG recommended (PETG for outdoor use)
- CAD Software: Tinkercad, Fusion 360, or similar for designing parts
- Microcontroller and compatible monitors: to create smart data loggers or visualizations

[1] https://project-spaces.eu/s4c/steam4climate-toolkit/steam4climate-toolkit-sustainable-housing/

Activity Steps & Instructions

7. Pre-Activity Preparation

It is important to ensure that all the electrical components as well as the crafting materials are easily accessible by the students. Allocate some time to familiarize yourself with the electrical circuit components before inviting your students to explore them.

Collaborative work is highly recommended, so make sure that you have a plan for inviting your students to form groups. Within a group role allocation may occur. This is perfectly acceptable but you should ensure that all the team members are happy with their roles. For example, some students may be involved more on crafting whereas some others more on electrical circuit making.

It is also essential to provide space for discussing scientific topics related to the project, adapting the depth and complexity of the discussion to the students' level. In addition, it is recommended to clarify from the beginning that the final project or outcome will be shared or presented, and to offer ideas on how this can be done (e.g., during a school event, online, or as part of a science festival).

Last, you can demonstrate ready-made constructions (either physical artefacts or photos) to help students visualize the different interrelated activities inherent in the project and inspire their work.

7.1 Electrical circuit making

This project focuses on one of the design strategies that can be used to make a building sustainable, namely the use of solar panels and their integration into a building. To this end, the students will first be involved in experimenting with different **electrical components and different circuit settings**, and then in crafting and creating a paper model of a building to embed the circuit, thus reflecting on various parameters relevant to design and engineering.

How does a Solar Panel work and what parameters affect its efficiency?

The first step is to encourage your students to test how the Solar panel works. To do this, encourage them to connect the Solar panel to the LED light, as shown in Figure 1.

Figure 1: Connecting the LED light to the Solar Panel by using two alligator clips. Connect the + and – terminals of the Solar Panel to the + and – terminals of the LED light.

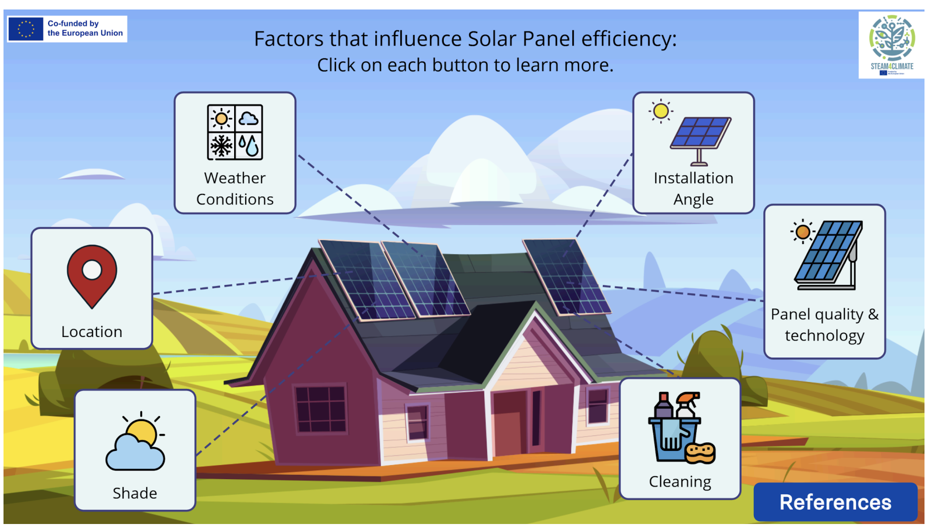
Then, ask your students to move the circuit to different locations inside or outside the classroom, to change the tilt angle of the solar panel, to partially or completely block direct sunlight by placing objects that act as shades, or to add some dirt (e.g. dust) to the photovoltaic panels, and observe if and how the efficiency of the solar panel is affected.

The following table summarizes the most common parameters/factors that affect the efficiency of a solar panel. Based on the observations of your students, you can use these factors as a starting point for further discussion on topics related to the use of solar panels and the possible design strategies.

Parameter/ Factor	**How it affects the efficiency of a solar panel.**
Location	Where you live affects how much sunlight your solar panels get. Places near the equator get more direct sunlight, while in the northern and southern hemispheres the amount of sunlight received depends on the season. Normally, in countries in the northern hemisphere (like Greece, Germany, Poland and France), it is best to install solar panels facing south to capture the most sunlight.
Tilt angle	Tilt angle is the angle that solar panels make with a horizontal plane. Therefore, if a panel was installed in a flat position, the tilt angle would be 0°, and if installed in a vertical position, the tilt angle would be 90°. The goal is to place a solar panel at a tilt angle that will capture as much direct sunlight as possible for a longer period of time. The more direct sunlight hits a solar panel perpendicularly, the more solar electricity is produced. A general rule for balanced year-round performance is to set the solar panel tilt angle equal to the geographical local latitude.
Shading	Shading from trees, buildings, or other obstructions can dramatically reduce solar panel efficiency. Even small shadows can block sunlight to portions of the panel, affecting the entire system's output due to the way panels are wired.
Weather conditions	Solar panels work on cloudy days but produce less power. Cooler temperatures can actually help panels work better, while too much

	heat can reduce their efficiency. Rain can clean the panels naturally, but consistent mild weather is ideal for the best performance.
Dirt/ Pollution	Dirty panels perform poorly. Dust, leaves, and bird droppings can block sunlight. Regular cleaning and maintenance are important to keep panels working at their best. Rain can help clean them, but manual cleaning might be needed in dry or polluted areas.
Panel quality & technology	Advances in technology lead to higher efficiency rates. Newer technologies like bifacial panels, which capture sunlight from both sides, and thin-film panels, which are lighter and more flexible, also contribute to better efficiency.

An [interactive animation](https://project-spaces.eu/learningcontent/steam4climate/scenario2/story.html)[2] is also available and accessible through QR code to help you and your students explore factors that affect the efficiency of the solar panels.



[2] https://project-spaces.eu/learningcontent/steam4climate/scenario2/story.html

How can solar energy harvesting be more efficient?

The next step is to introduce your students to ways of using the harvested solar energy efficiently. To do this, they need components that can **a.** store the harvested solar energy and **b.** distribute it to different devices. This can be done by using the Solar Store component. Therefore, encourage your students to use the Solar Store and connect it to the Solar Panel as shown in Figure 2 (i.e. by respectively connecting the + and – terminals of the Solar Panel to the + and – terminals of the Solar Store, and by connecting the Level terminal to the Enable terminal of the Solar Store, so that the circuit works in stand-alone mode). Then instruct them to expose the Solar Panel to sunlight (or another light source) and encourage them to observe whether the in-built LED lights up and to count how long it takes.

Note: the in-built LED indicates whether or not the Solar Store has enough energy to power a connected device.

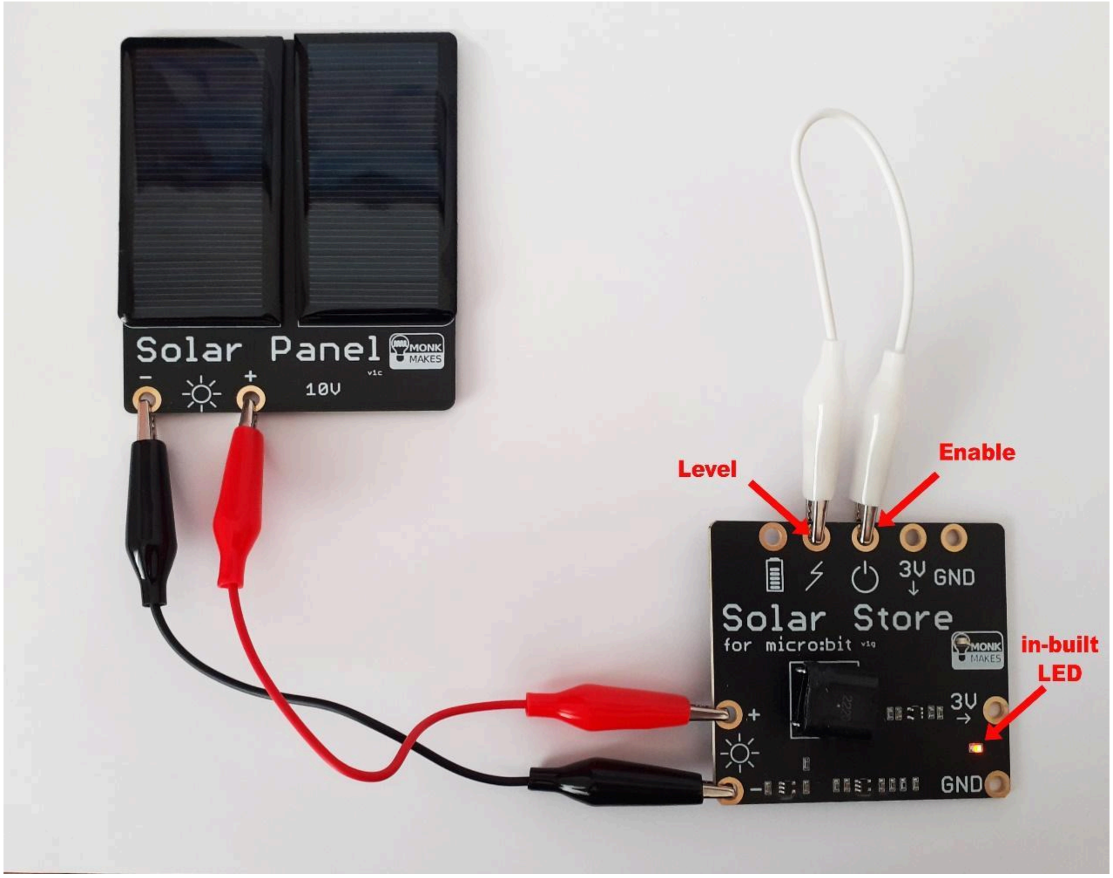


Figure 2: Connecting the Solar Panel to the Solar Store

The next step is to connect one of the available devices (i.e. the LED light as shown in Figure 3, or the DC motor as shown in Figure 4) and observe how long it takes for these devices to consume all the stored energy.

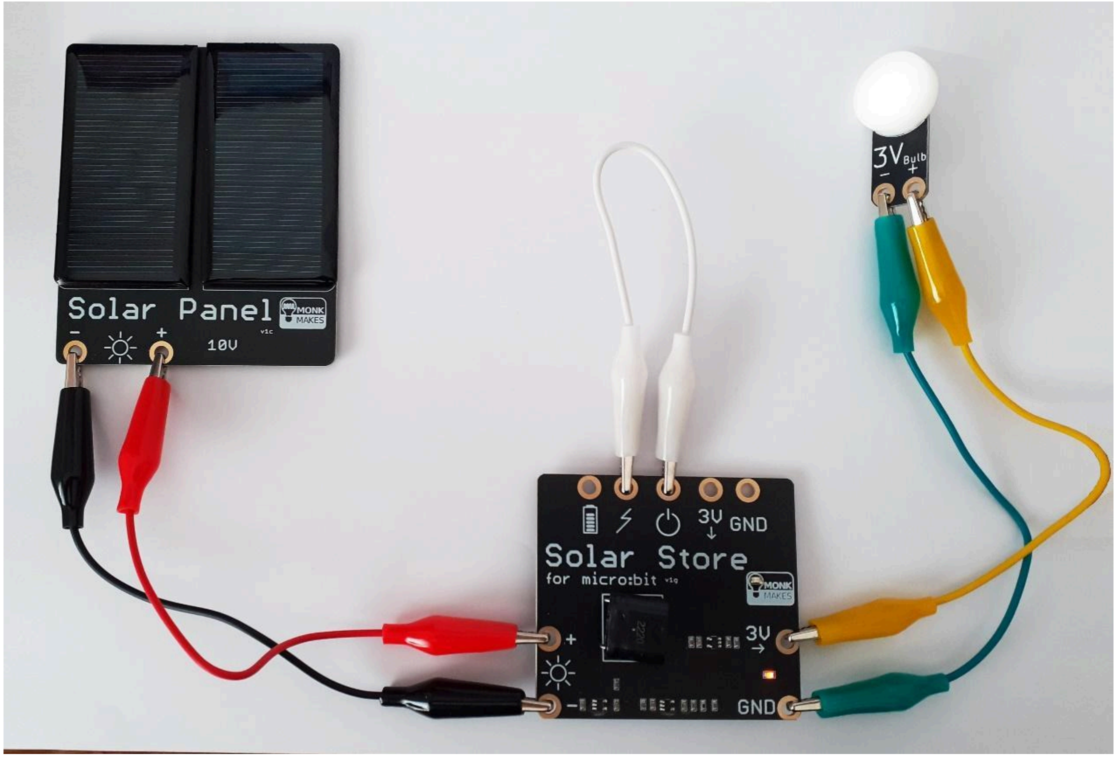


Figure 3: Connecting the LED light to the circuit

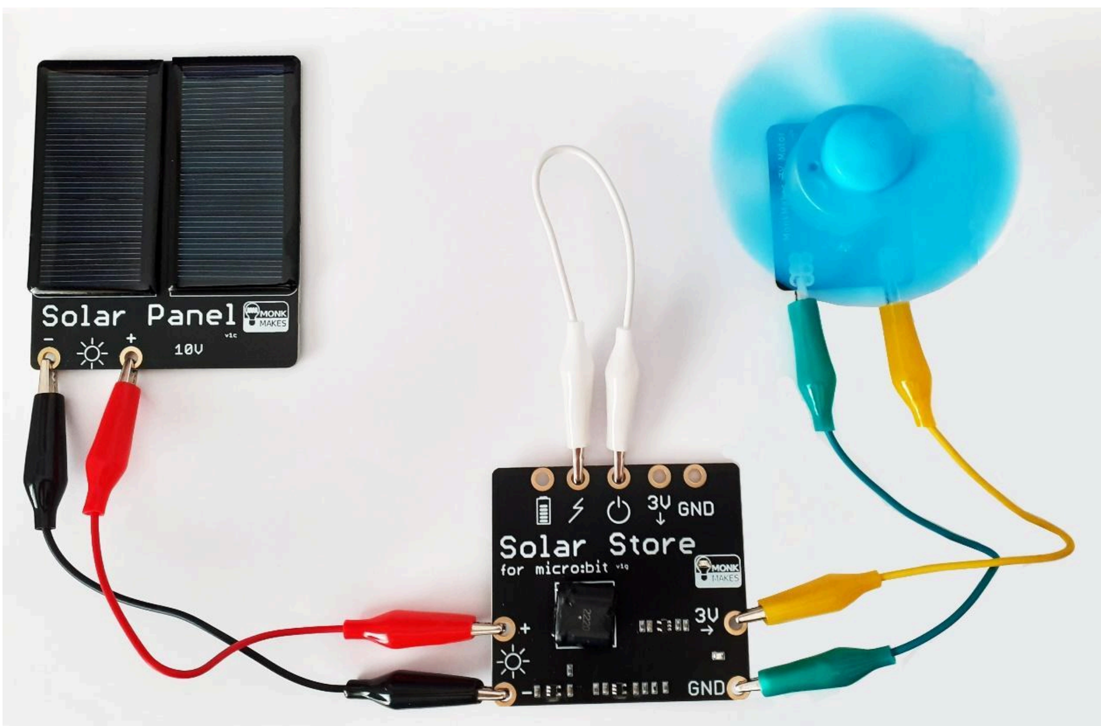


Figure 4: Connecting the DC motor to the circuit

7.2 Programming to use the stored solar energy wisely

As an optional step (and prior to crafting) you can show to your students how they can use the stored solar energy wisely to have a more efficient energy system.

One way is to advise them to create a manual switch by using two alligator clips (instead of one) and connecting one to the Level terminal and the other to the Enable terminal. When the two alligator clips are connected the device will work and when the two clips are disconnected the device will stop working.

Another way is to use the BBC micro:bit[3] and program the circuit to use the stored energy under certain conditions.

[3] https://microbit.org/

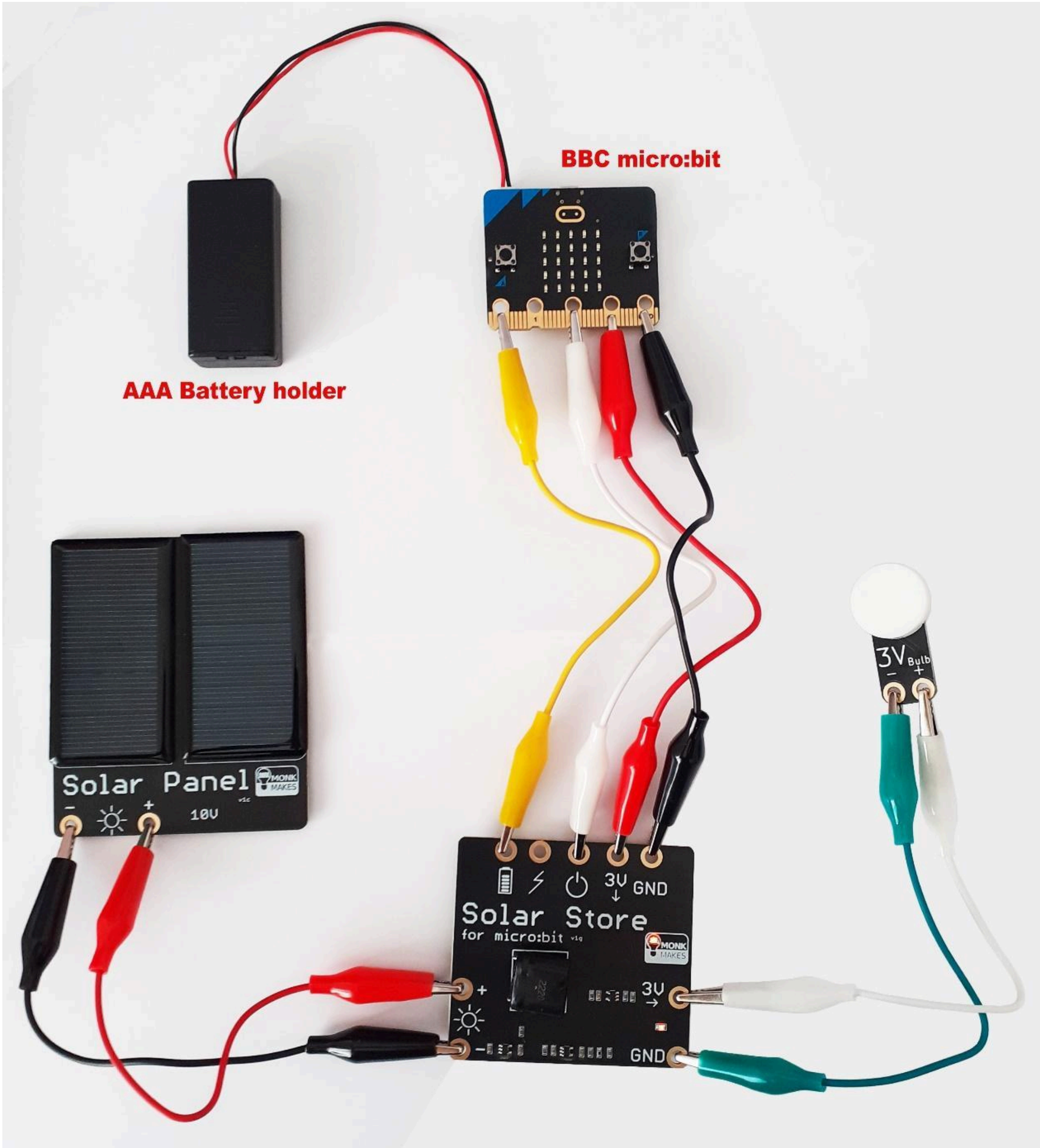


Figure 5: Connecting the BBC micro:bit to instruct the LED light to light up when the ambient light level is below a certain threshold

Encourage your student to create the circuit shown in Figure 5.

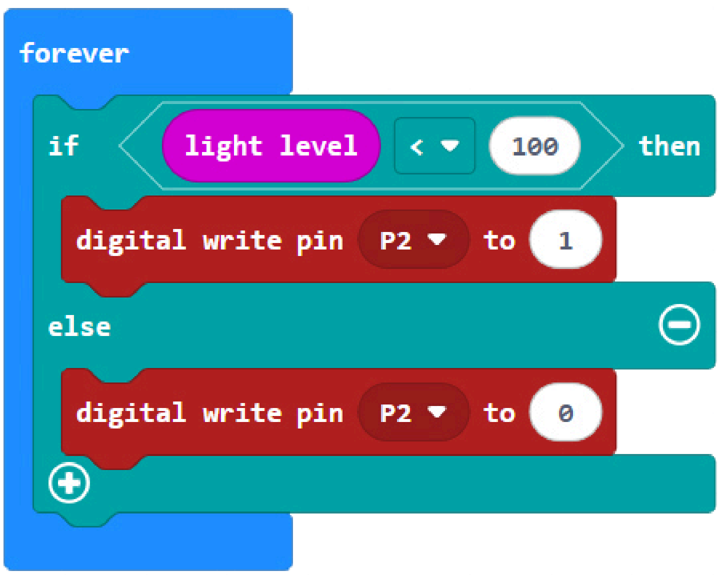
Note 1: By connecting the Charge% terminal to the P0 pin of the micro:bit, the micro:bit has access to the stored solar energy. This stored energy is distributed to the circuit when the Enable terminal is activated. The Enable terminal is connected to the P2 pin of the micro:bit. Therefore, when the P2 pin is pressed (P2 = 1), it allows the distribution of the stored solar energy to the circuit.

Note 2: The micro:bit must be connected to an external power source (e.g. battery holder, solar bank, computer etc.).

Then ask your students to open the Microsoft Makecode software (available online here: https://makecode.microbit.org/). The aim is to program the light sensor of the micro:bit board (i.e, the LED display) to use the stored energy to light up the connected LED light, when the ambient light falls below a certain threshold.

This can be done by assembling and uploading to the micro:bit the following script. The script allows the distribution of the stored solar energy, when the ambient light falls below the threshold of 100.

Note: By default, the light level ranges from 0 (dark) to 255 (bright).



7.3 The crafting process

For the crafting process it is important to

- **Encourage Contextual Integration:** encourage students to integrate the circuit into a paper model of a building (e.g. their school building) to create a scaled physical simulator.
- P**rovide Diverse Tools and Materials:** make a variety of tools and materials available to all and help students decide which materials to use. Encourage the use of recycled materials or the reuse of everyday objects
- **Promote Thoughtful Planning:** encourage students to plan the design of their models and think about how the circuit will be embedded in their paper model
- **Allow Time for Crafting and Boost Role Allocation** Ensure students have enough time to complete their projects and encourage collaboration by assigning roles within groups. This could include roles like designer, electrical circuit maker, programmer, materials coordinators, presenter and more to foster teamwork and efficiency.
- **Provide Inspirational Examples:** Share examples of ready-made constructions to inspire students and help them visualize the possibilities for their own designs.

8. Examples of Artefacts

From ready made mock ups (that need to be assembled) to re-usable materials and mixed solutions, the range of artefacts that can be developed is truly impressive. The process of working on a model, planning and designing an artefact can be a fun, creative and engaging process with strong educational potential.

8.1 With ready made mockups

A set of ready-made mockups[4] are available for you to print. This might save some time. You can consider offering your students the opportunity to assemble and customize the readymade models (see pictures below) based on their needs and personal preferences (i.e. colouring, adapting sizes, creating more robust bases, enhancing the design with everyday materials).

Figure 6: Modifying an empty shoe box to turn it into a paper model of a building

[4] https://project-spaces.eu/s4c/steam4climate-toolkit/steam4climate-toolkit-sustainable-housing/

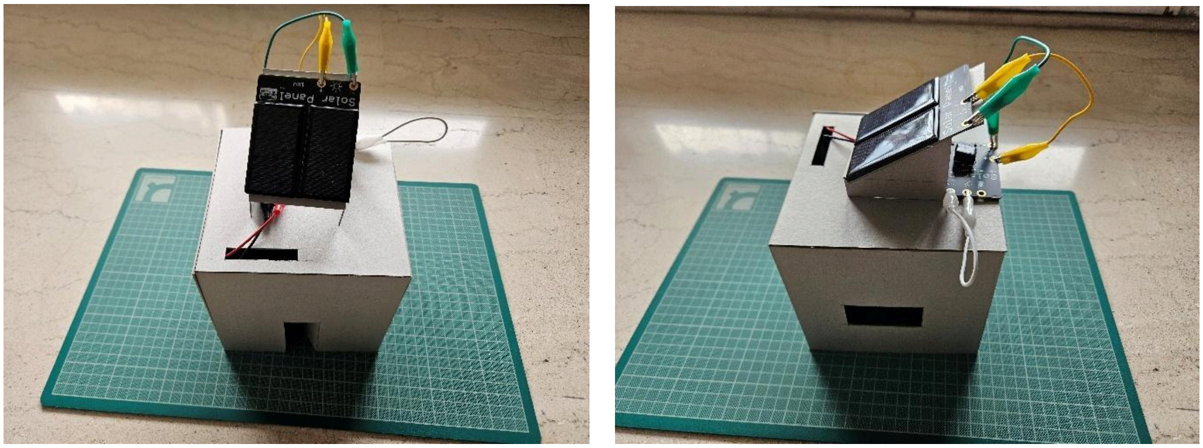


Figure 7: Modifying an empty shoe box to turn it into a paper model of a building

8.2 Using everyday materials

Below you can see an indicative example of creating a paper model by using an empty shoe box. This example shows how the circuits from the first (*How does a solar panel work*) and the second (*How can solar energy harvesting be more efficient*) activity can be embedded in the paper model.

Figure 8 shows some modifications made to a shoe box to turn it into a paper model of a building.

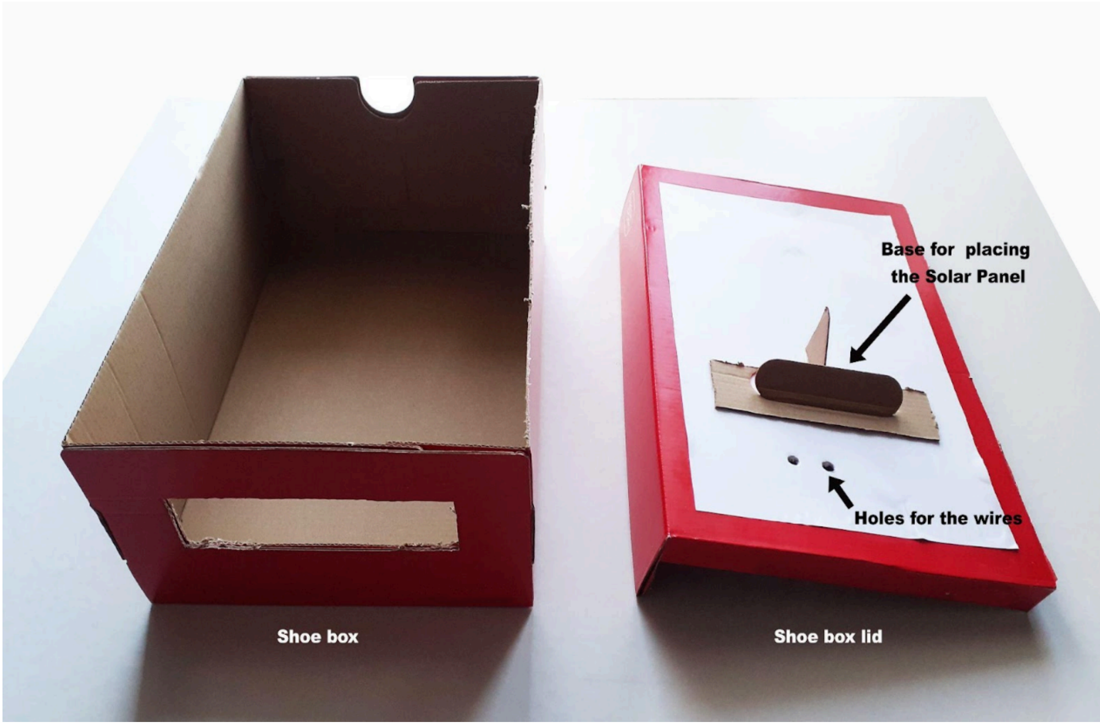


Figure 8: Modifying an empty shoe box to turn it into a paper model of a building

The hole in the side of the box, which functions as a handle, was used as a starting point for creating a wide window. To this end, the grayed area and the handle (marked in Figure 9) were cut off/removed, creating an opening to the box interior.

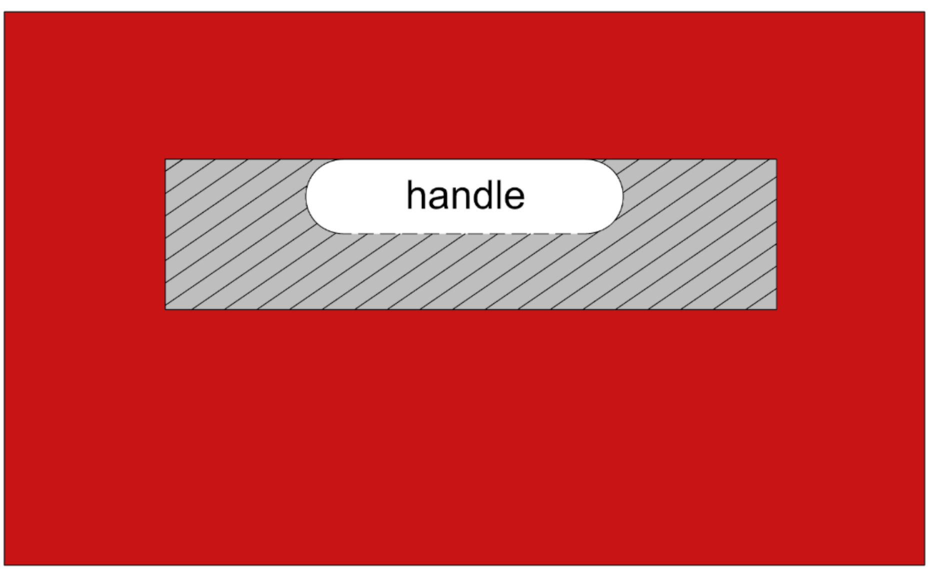


Figure 9: Diagram showing the part of the box that was cut off to create a wide window

The removed part was then used to create a base for placing the Solar Panel on top of the shoe box lid and in a tilt angle equal to the local latitude (Figures 8 and 9). For this purpose, and to fix the position of the solar panel and have a more rigid structure, a small piece of cardboard (which was cut lateral) was used (Figure 10).

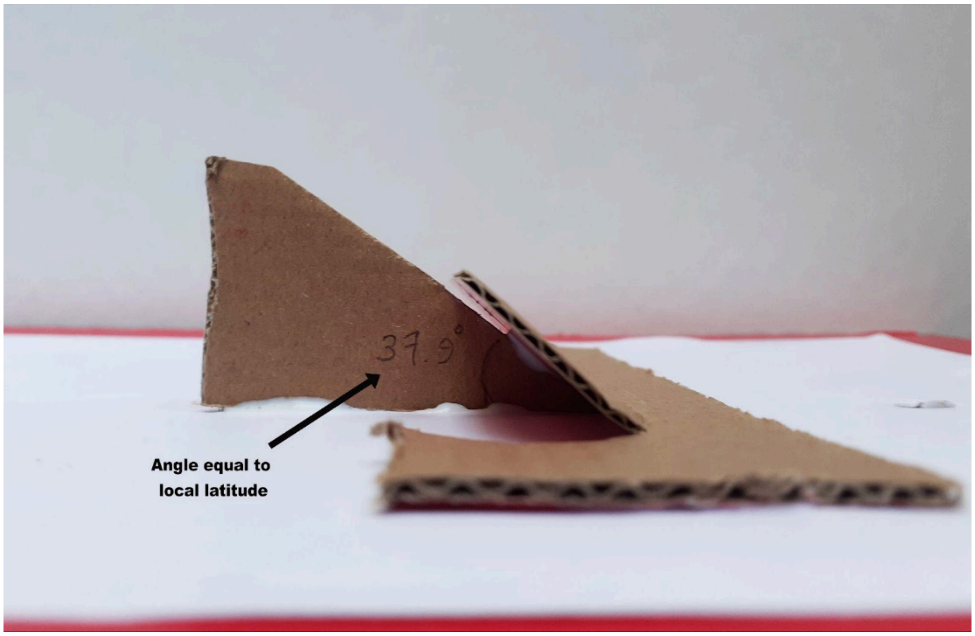


Figure 10: Using a small piece of cardboard to fix the position of the solar panel and help on creating a more rigid structure

Two holes (Figure 8) were also opened to the lid of the shoebox to facilitate the connection of the solar panel (Figure 11) to the LED light (which was placed on the bottom side of the lid, as shown in Figure 12).

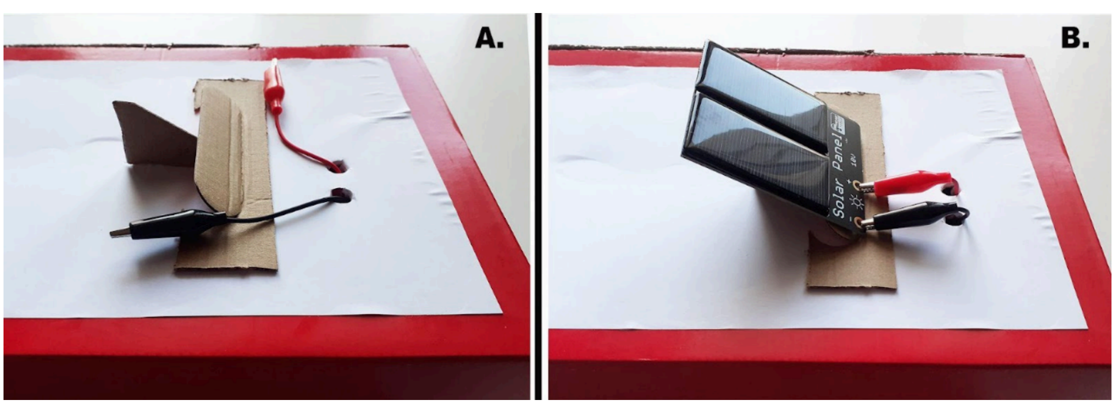


Figure 11: Passing two alligator clips through the holes and connecting the solar panel

Figure 12: Connecting the alligator clips to the LED light, which is placed at the bottom side of the lid

Figure 13 shows a sectional view of the paper model with all the components in place, while Figure 14 shows only the interior of the paper model with the LED light on.

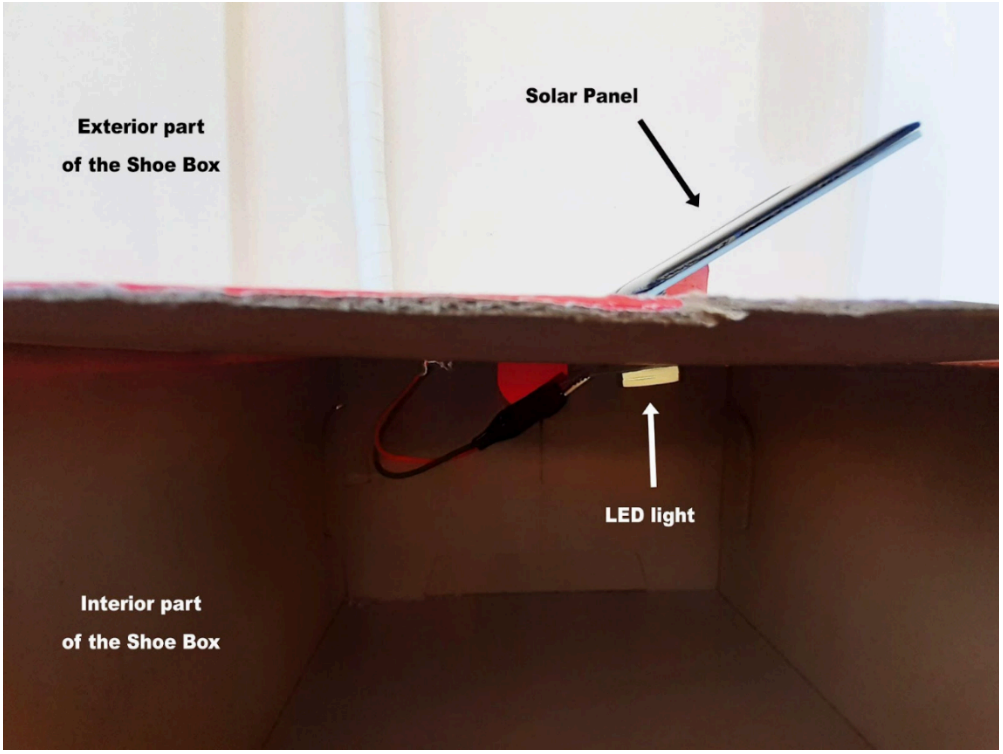


Figure 13: Sectional view of the paper model

Figure 14: Interior of the paper model

This paper model can be further modified when more components are added (the solar store for example as shown in Figures 15 and 16).

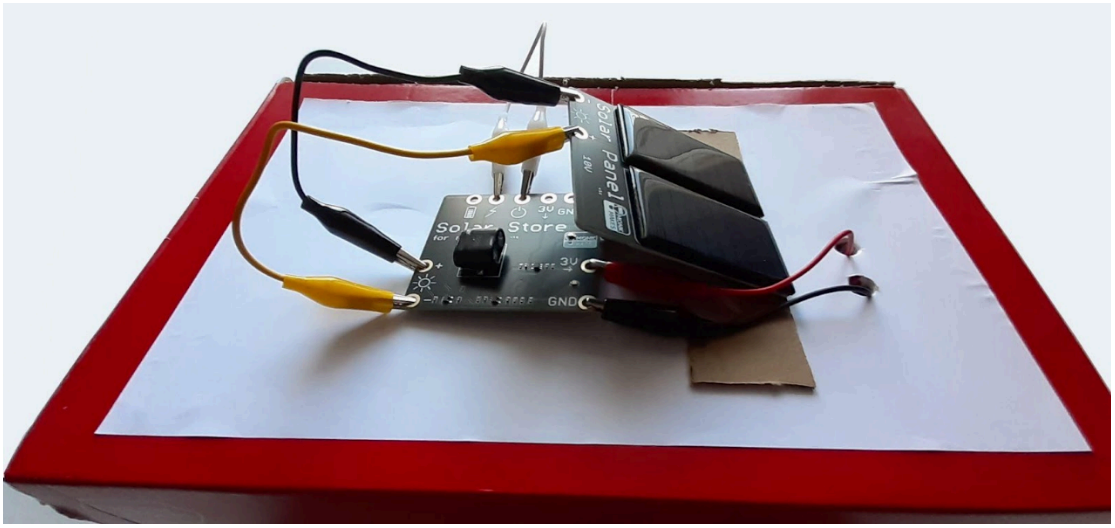


Figure 15: Adding the solar store components - setting 1

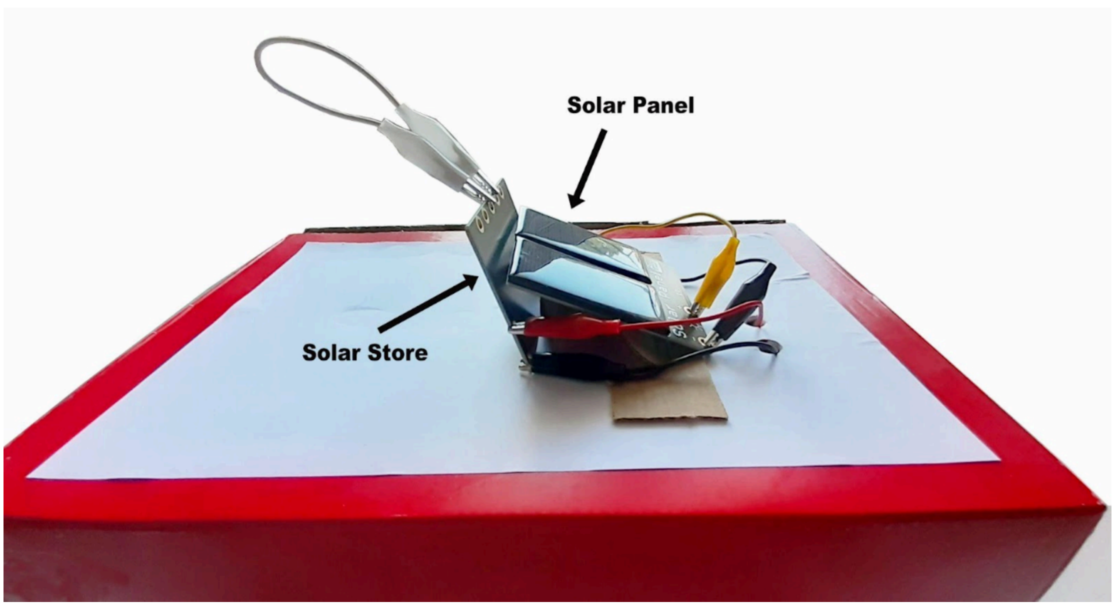


Figure 16: Adding the solar store components - setting 2

Post lesson follow up & summary

9. Discussion Topics

Discussion Topic 1: What factors can affect the efficiency of a solar panel?

The table on page 4 outlines several factors that can impact the efficiency of a solar panel, such as location, orientation, tilt angle, and more. Present these factors to the class by writing them on the whiteboard or displaying them visually (without the short descriptions).

Divide the students into groups and assign each group 1-2 factors to research. Encourage them to search for information online and use the "interactive element" to explore these factors in more depth. Once the research is complete, have each group present their findings to the class, providing a summary of how their assigned factors affect solar panel efficiency and any important details they discovered.

Encourage an open discussion where students can compare their findings, ask questions, and relate the factors to real-world scenarios, such as installing solar panels on homes or public buildings.

Discussion topic 2: How do the seasons affect the placement of solar panels?

This short animation[5] (accessible also through QR code) shows why there are different seasons and how the seasons affect the different temperatures on the Earth's hemispheres. Present this video in the classroom and encourage your students to think about how these parameters can affect the placement of solar panels in terms of orientation and tilt angle.

Possible questions that can be raised to trigger discussion: How would the efficiency of a solar panel differ between a country near the equator and one farther north? What adjustments would need to be made in each location to maximize efficiency?

[5] https://youtu.be/JY2K9yuRnJ0?si=CcFbDsVj8e37MbU_

Discussion topic 3: Why is it important to design sustainable buildings?

Several amounts of greenhouse gasses and global emissions are related to the energy consumption of operational facilities used in buildings (e.g. heating or cooling systems, lighting, boilers etc.). Sustainable building design strategies can significantly minimize these emissions thereby mitigating climate change. With this in mind, discuss with your students the different design strategies that can be used to make a building sustainable. You can also encourage your students to search on the internet for examples of sustainable buildings and information about their impact on the climate.

Discussion topic 4:

Interviews with experts can help students build a comprehensive understanding of how renewable energy sources, such as solar energy, play a crucial role in addressing the impacts of climate change in the light of Sustainable Housing.

STEAM4Climate - Talk with a Power System Engineer https://youtu.be/1HkZFg0ikm8	

10. Extensions

The solar-powered house project can be further enriched through a range of creative and more advanced extensions that deepen students' understanding of renewable energy, design, and engineering principles. Beyond powering a simple LED light, students can explore how different materials used in the construction of the house affect its insulation properties by measuring the interior temperature under various conditions. They can design and implement basic cooling mechanisms that activate automatically when the temperature exceeds a certain threshold, introducing them to sensor-based control systems. To improve the functionality of their model, they may add additional LED lights or other small devices, or experiment with integrating an alternative power source—such as a small battery or wind-powered generator—to ensure continuous operation even on cloudy days. Furthermore, students can enhance the structural design process by 3D-printing components of the house or using a laser cutter to fabricate parts from wood or balsa wood, thereby gaining experience with digital fabrication tools. For more ideas and additional resources to enrich or extend this project, visit https://project-spaces.eu/s4c/steam4climate-toolkit/steam4climate-toolkit-sustainable-housing/ or scan the QR code.

Appendix

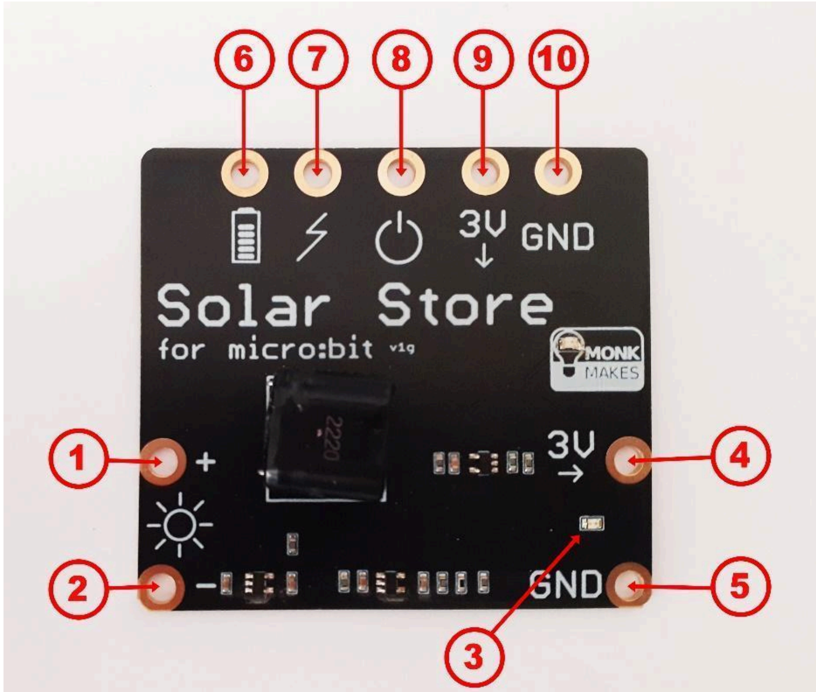
11. Description of basic electrical components

Solar Panel

The solar panel included in the kit is the component that converts sunlight into electricity. It has two photovoltaic (PV) cells **(1)** that harvest solar energy, by generating an electrical charge when exposed to sunlight, through physical and chemical processes that contribute to the release of electrons. It also has two terminals for connecting the solar panel to other components or devices. The positive terminal + **(2)** is the voltage which supplies the electricity and the negative terminal – **(3)** is the ground.

It can supply up to 10V. Therefore, the current produced is relatively low and safe.

Solar store board



The solar store is the component that helps to store the harvested electricity and it consists of several terminals:

The + **(1)** and – **(2)** terminals are **input** terminals, used to connect the Solar Panel and store the solar energy. These terminals can accept a voltage of up to 10V.

The 3V **(4)** and GND **(5)** terminals are **output** terminals for connecting devices that will use the stored energy (e.g. the LED light or DC motor). The connected devices will work if there is sufficient stored energy [indicated by the in-built LED light between these two terminals **(3)** and whether it is on (sufficient stored energy) or off (insufficient stored energy)].

Terminals **(4)** and **(5)** cannot be used if terminal **8** (or Enable) is not enabled. “Enable” **(8)** is an **input** terminal that allows power output to the attached devices.

Terminal **(6)** is an **output** terminal that is called “Charge%” which acts as an indicator of the stored charge. It produces a voltage between 0 and 3V and can be connected to one of the P0, P1, and P2 micro:bit pins.

Terminal **(7)** is an **output** terminal and is called "Level". It produces a voltage between 0 and 5V and can be connected to the "Enable" **(8)** terminal to create a loop that automatically enables the connected devices to work (e.g. turn on an attached LED light) when there is sufficient stored energy. **Bear in mind** that the "Level" should never be connected to the BBC micro:bit board.

Terminal **(9)** is an **input** terminal that supplies power to the Solar Store, to enable "Charge%" **(6)**. It is connected to the 3V pin of the micro:bit, while terminal **(10)** is connected to the GND of the micro:bit.

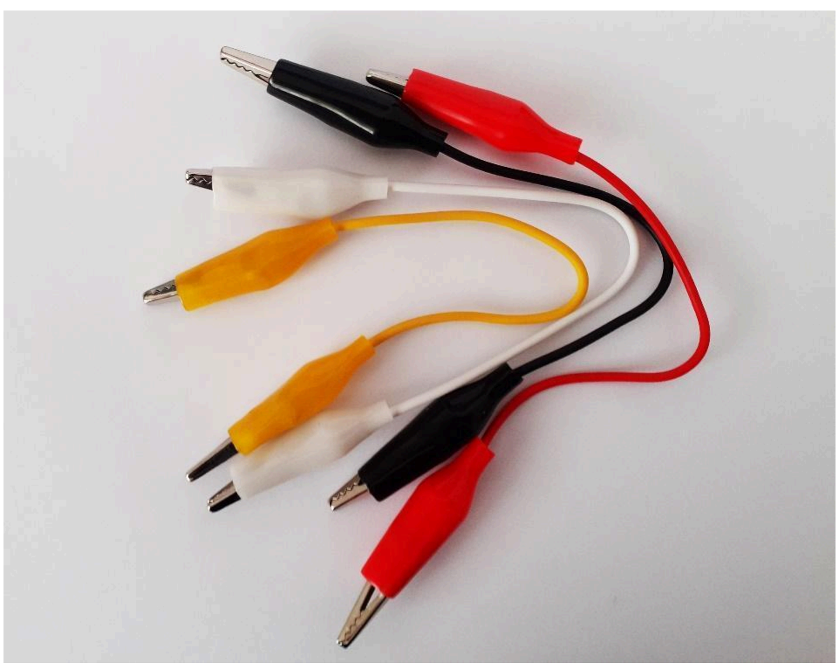
LED light

The LED light is an output device that can be directly connected to the solar panel, or to the output terminals **(4)** and **(5)** of the Solar Store. It has two terminals (+) and (-) to allow connection to the aforementioned devices and operates with a current of 3V. If the current generated is sufficient, the LED light bulb will light up.

DC motor

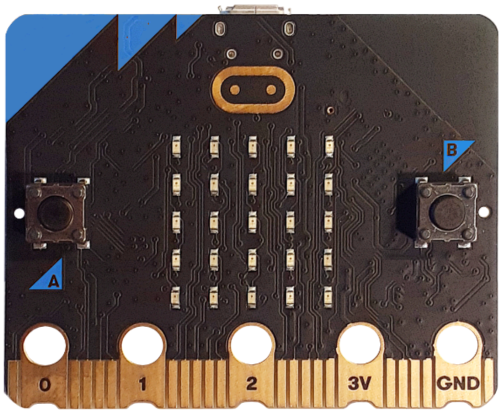
The DC motor is an output device that can be connected to the Solar Store through the **+** and **–** terminals. A propeller can be attached to the shaft of the motor, turning it into a cooling fan.

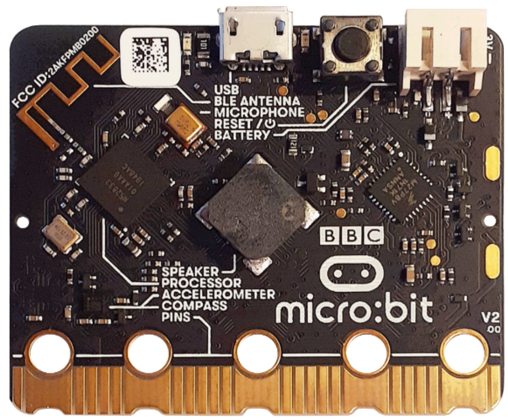
Alligator clips



Conductive wires with alligator clips at the ends to facilitate circuitry. The colors are indicative and do not affect their conductivity.

BBC micro:bit board





A pocket size microcontroller, primarily designed for educational purposes to introduce young learners to the ICT field in a simple and intuitive way. Having several in built input and output devices, micro:bit offers a handy solution for the creation of a number of STEM related interesting projects, without the need of extra hardware.