STEAM4Climate Teacher’s Guide
to Project-Based Climate Education

Project: DIY wind turbine

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EU Project Consortium

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Table of Contents

Introduction

UN Sustainable Development Goals

1. Learning Overview

In this project, students will engage in a creative hands-on activity where they will design and build their own small-scale wind turbines to generate electricity for a DIY model house or other creative models. This interdisciplinary project will combine elements of electrical circuit design, engineering, and crafting, allowing students to explore key STEAM concepts in a fun and practical way. Additionally, students will gain firsthand experience with the fundamentals of renewable energy production by harnessing wind power.

Key Concept:

Duration: 6 hours (more time can be allocated for extending the project idea, building DIY propellers or experimenting with different materials)

Number of Sessions: 2 or 3

Target Age Group: secondary school, 12+

2. Learning Objectives

This project offers a comprehensive learning experience that integrates creativity with technical skills, providing students with a holistic approach to understanding renewable energy and electrical engineering concepts.

In particular, students will be able:

- To understand the fundamental principles and operation of wind turbines
- To identify and describe the key components of a wind turbine
- To construct and operate a small-scale wind turbine capable of powering a LED or a series of LEDs
- To experiment with various electrical circuit configurations and solutions
- To explain how kinetic energy turns into electricity
- To integrate crafting and circuit making to create interactive and functional handmade models
- To select and utilize everyday materials and crafting tools effectively for their projects
- To recognize and explain the function of different electrical components within a circuit
- To reflect on the broader implications of renewable energy and visualize the entire process of electricity production using wind turbines with the support of their teachers.

3. Methodology

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

- **Hands-on experimentation:** bringing together electrical circuit making and artefact construction using everyday tools and objects
- **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 wind generated electricity and/or explore limitations of the current set up.

- **PBL Self-science:** Encourage discussions about the practical implications

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: Beginners can easily get started with basic tools like wires, led, DC motor and a readymade propeler. Engagement in the construction of the wind-turbine model is also encouraged using everyday materials. To ease this stage ready-made mockups are also available for students to assemble.

High Ceiling: They can experiment with different types of propellers, optimize blade design for efficiency, explore energy storage options, or even design and 3D-print their own turbine parts. By integrating sensors, microcontrollers, or data collection tools, they can transform their simple turbine into a more sophisticated renewable energy system.

Wide Walls: The project supports diverse pathways for exploration and expression. Students can personalize their turbines, relate them to local environmental challenges, or integrate them into broader STEAM projects—such as creating hybrid systems with solar panels or building narratives around sustainable communities.

Whether indoors or in the field, every learner’s path is different and each wind turbine becomes more than just a model. It becomes a story of curiosity, effort, and environmental awareness.

Materials

4. Materials Included in Toolbox for basic version

- DC Motors
- LED light(s)
- Wires/ Crocodile clips
- Multimeter
- Different types of propellers
- Breadboard (Mini) - *Optional*
- Resistors – *Optional*

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 wind turbine model that needs to be assembled.

6. Components for extended version

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

- 3D Printer: For printing custom parts (e.g., blades, hubs, housings)
- Filament: PLA or PETG recommended (PETG for outdoor use)
- CAD Software: Tinkercad, Fusion 360, or similar for designing parts
- Anemometer: To measure wind speed in different environment
- Microcontroller and compatible monitors: to create smart data loggers or visualizations

[1] https://project-spaces.eu/s4c/steam4climate-toolkit/steam4climate-toolkit-diy-wind-turbine/

Activity Steps & Instructions

7. Pre-Activity Preparation

Ensure that all electrical components and crafting materials are easily accessible to students. Allocate time to familiarize yourself with the electrical circuit components before inviting students to explore them.

Collaborative work is highly recommended, so plan ahead for organizing students into groups. Role allocation within each group may naturally occur, and while this is acceptable, it is important to ensure that all team members are comfortable with their assigned roles. For example, some students may focus more on crafting, while others may engage more with the electrical circuit assembly.

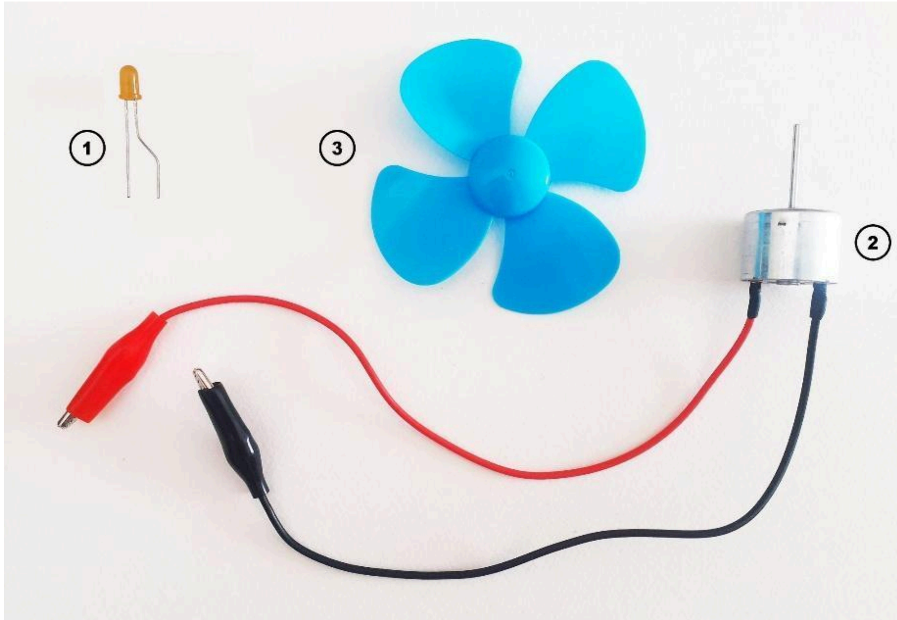
It is also essential to communicate early on that the final project will be published or showcased. Provide students with potential ideas for how this can be done—whether through a school event, an online platform, or as part of a science festival. You can make the final decision together with the students.

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

7.1 Electrical circuit making

The project brings together 2 different but interrelated activities: **electrical circuit making** and **crafting.**

The following image shows the components needed to build the circuit of a wind turbine. Specifically, you need a LED light (1), a DC motor (preferably with wires pre-attached) (2), and a propeller (3).

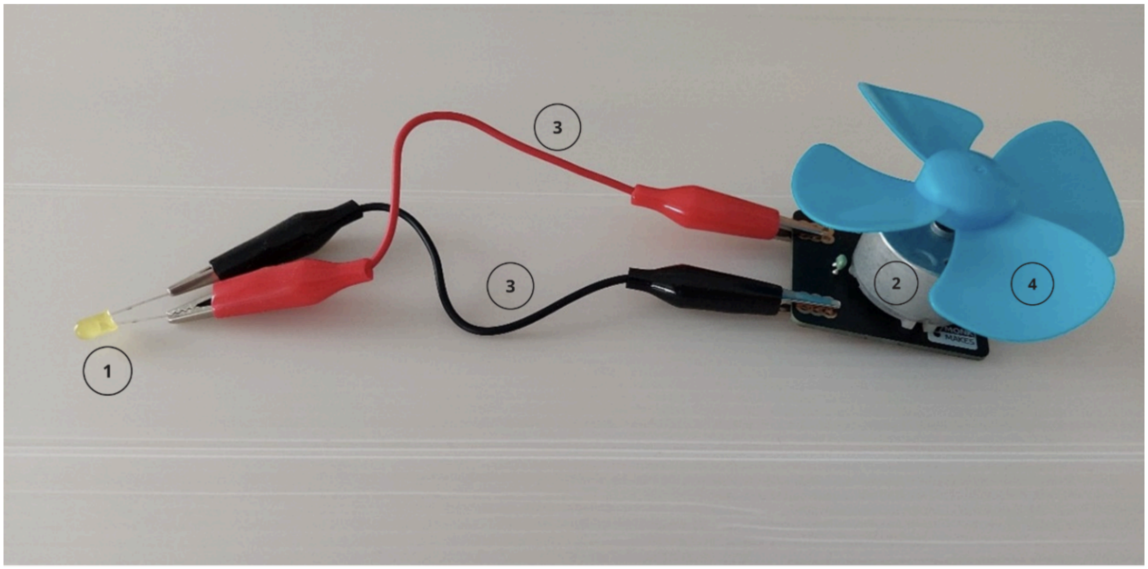


The first step is to create the circuit and ensure that the DC motor and the led are properly wired up to the circuit. The DC motor harnesses the wind (including ways to simulate wind, such as blowing with a hairdryer or your mouth) to light up the LED.

About the DC Motor

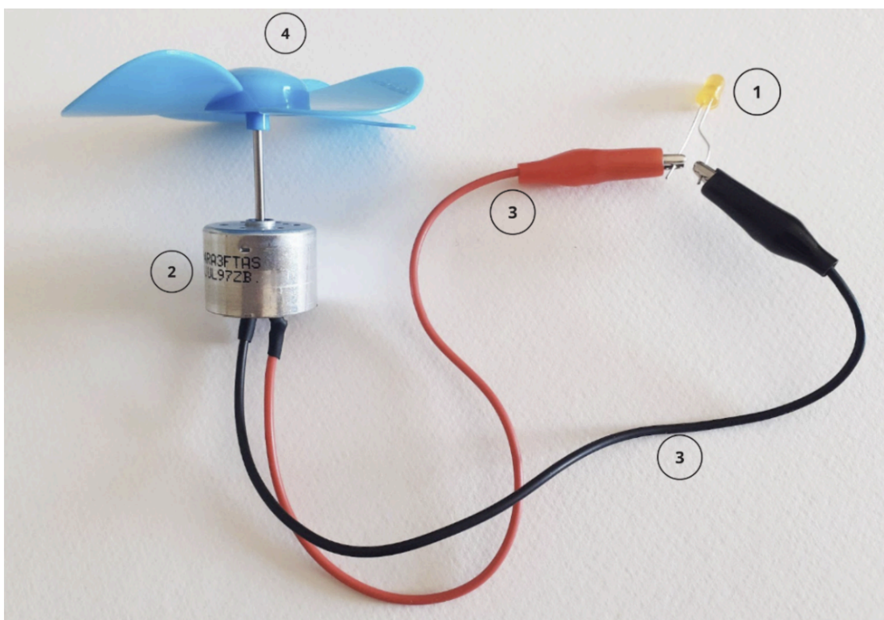
The DC motor is typically designed to convert electrical energy into mechanical motion. In other words, it uses electrical energy to produce motion. However, in this project we are going to use the DC motor **in reverse** to create electric current. By manually turning the motor's rotor (using wind power), it can function as a generator producing electrical energy.

The pictures below show different 2 types of DC motors (available in the toolkit) and how these are connected to the circuit.



① Led ③ Wires

② DC Motor ④ Propeller

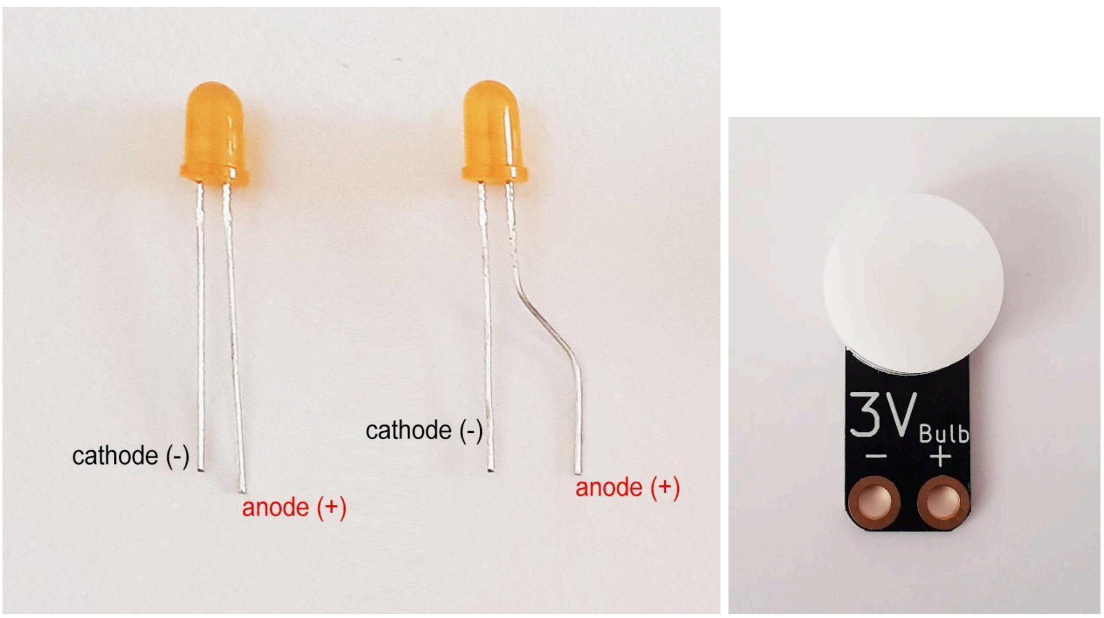


① Led ③ Wires

② DC Motor ④ Propeller

About the LED light

A typical LED light has two leads, the anode (+) and the cathode (-). The anode is the longer lead, and the cathode is the shorter one. In some circuit diagrams, or to facilitate the circuit making process, the anode may be bent so that the two leads are not accidentally connected, resulting in a short circuit. In the toolkit another type of led is also available (see right picture below) where the anode and the cathode are notated with the characteristic symbols of (+) and (-).

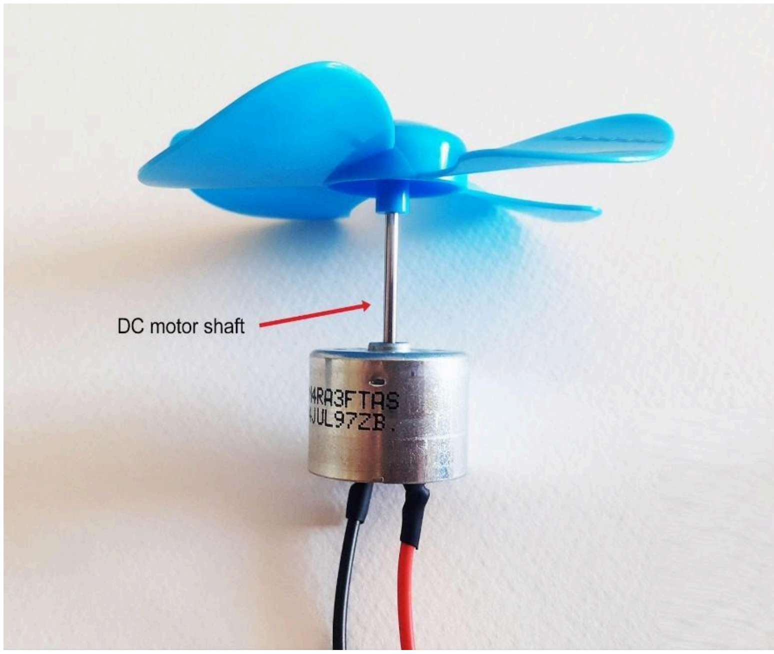


Light leds available in the STEAM4CLIMATE toolkit

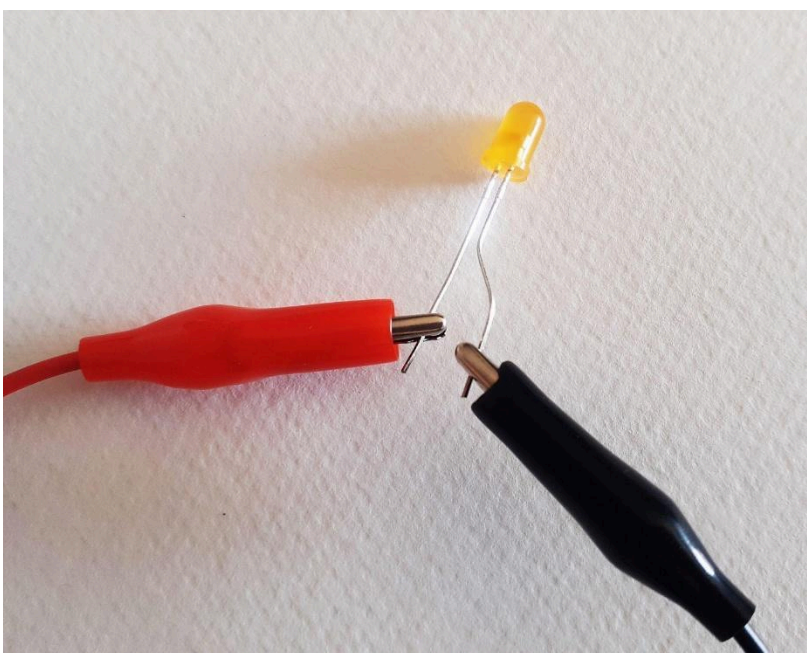
By connecting a led to the circuit we have an easy readout of the generation of the power. Keep in mind that LEDs function only when connected in the correct polarization within a circuit. If the LED does not light up, try reversing the leads to ensure that it is properly oriented.

Step-by-step Instructions for making the circuit.

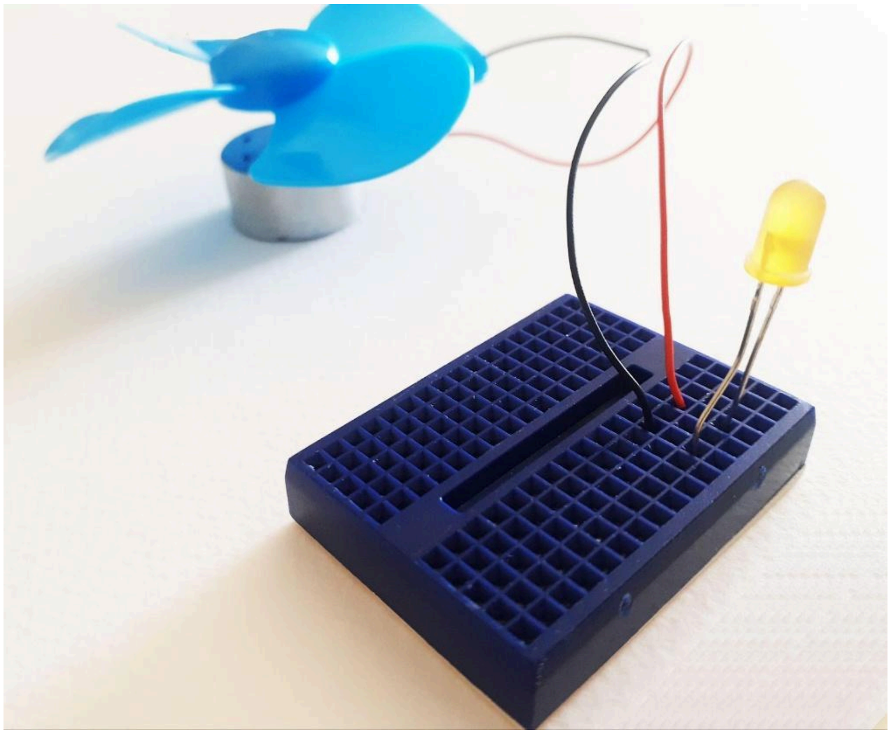
- First, snap the propeller onto the DC motor shaft.



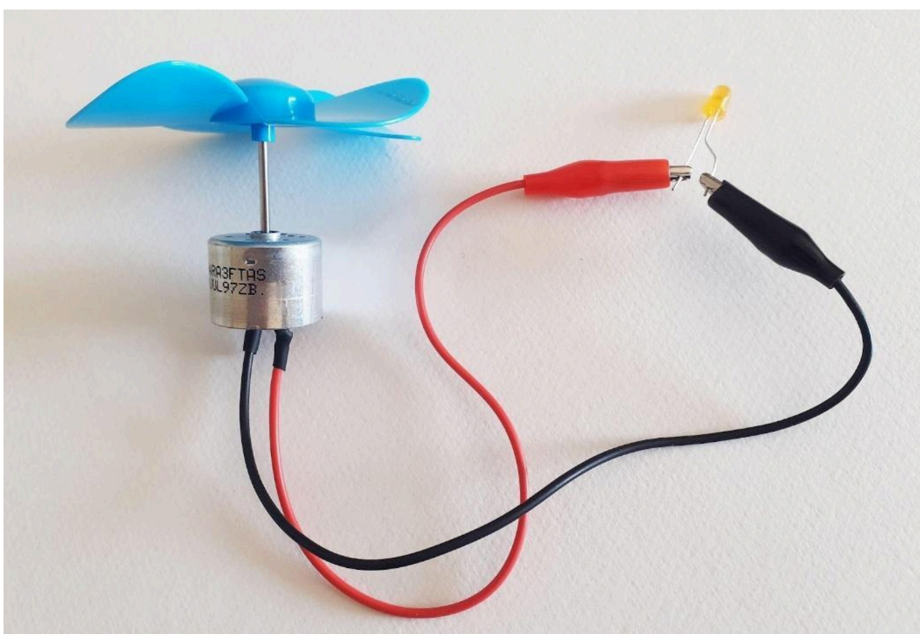
- Then, connect the wires to the leads of the LED light.

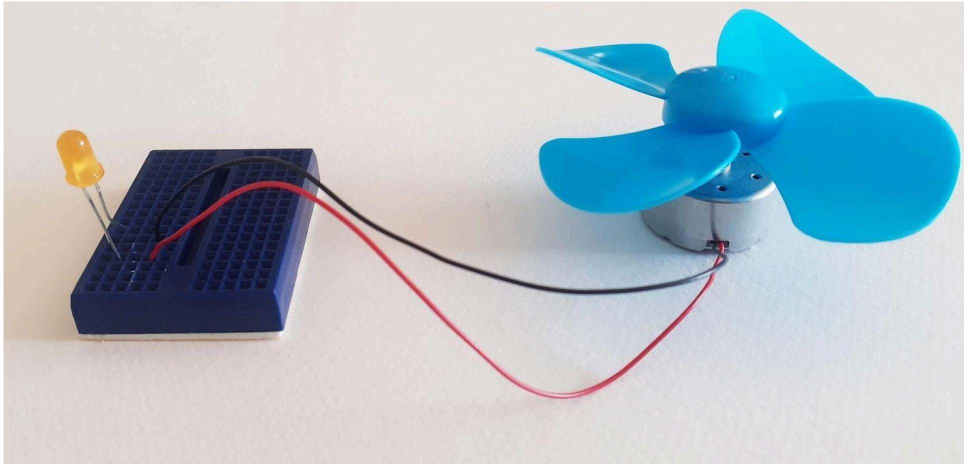


- If the DC motor wires do not end in alligator clips, you can use a mini breadboard to connect the DC motor to the LED light.



- At the end of the process, the circuit may look like the following images:





7.2 The crafting process

When guiding students through the crafting process of the DIY wind turbine project, consider the following practices to enhance creativity and problem-solving:

- **Encourage Contextual Integration:** Inspire students to integrate their circuits into a meaningful context. For example, the wind turbine could light up a house, streetlights, a lighthouse and more. This contextual thinking adds relevance and creativity to the project.
- **Provide Diverse Tools and Materials:** Make a variety of tools and materials available to the students. Help them make thoughtful choices by encouraging the use of recycled materials or everyday objects in their models. This promotes sustainability while fostering creativity in using familiar resources in new ways.
- **Promote Thoughtful Planning:** Guide students to plan their designs carefully, thinking critically about how the circuit will fit into their model. Emphasize the importance of integrating the technical and aesthetic aspects of their creation.
- **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, materials coordinators, presenter and more to foster teamwork and efficiency.

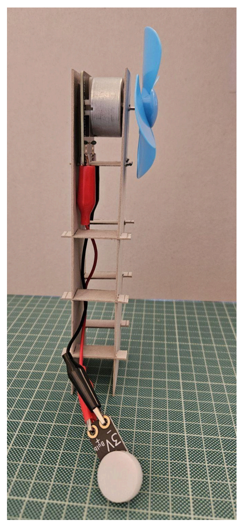
- **Provide Inspirational Examples:** Share examples of ready-made constructions to inspire students and help them visualize the possibilities for their own designs.

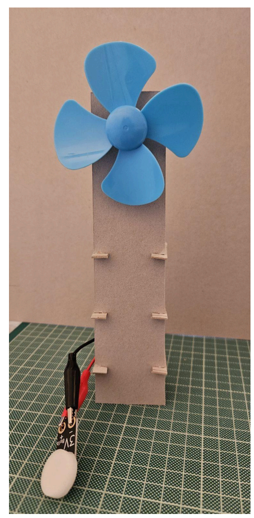
8. Examples of Artefacts

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 are available for you to print[2]. This might save some time. You can consider offering your students the opportunity to assemble and customize the readymade models based on their needs and personal preferences (i.e. colouring, adapting sizes, creating more robust bases, enhancing the design with everyday materials).

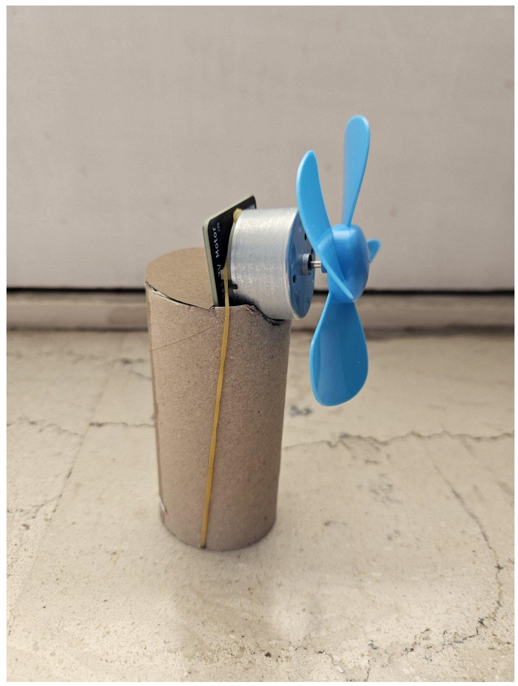




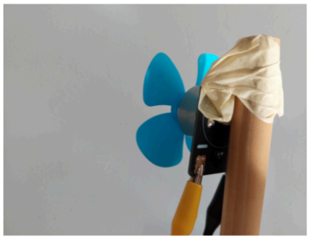
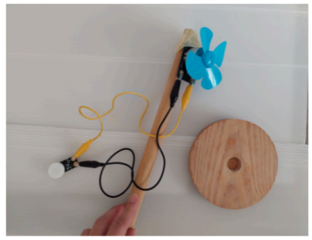
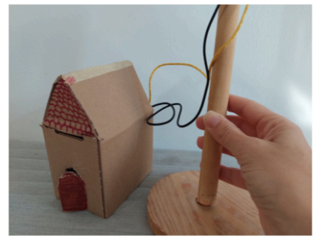
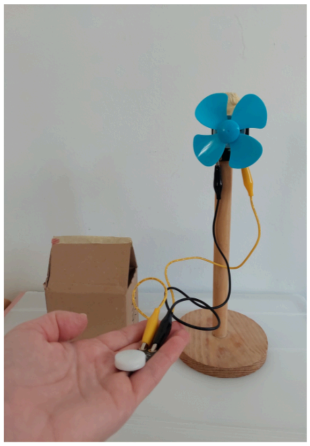
[2] https://project-spaces.eu/s4c/steam4climate-toolkit/steam4climate-toolkit-diy-wind-turbine/

8.2 Using everyday materials

In the example below a toilet paper tube and a rubber band were used to create the model of the wind turbine. The DC motor and the propeller were attached to the top and the rubber band was used to stabilize the structure. Further modifications can be introduced to ease the wiring and the connection between the DC motor and the led light.

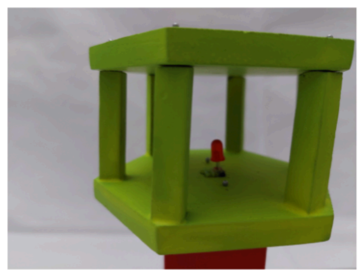
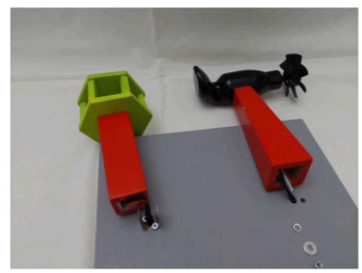



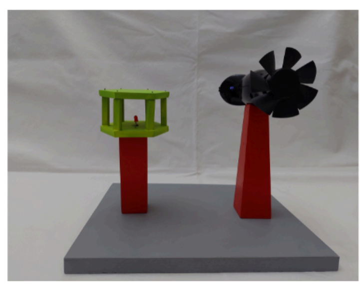
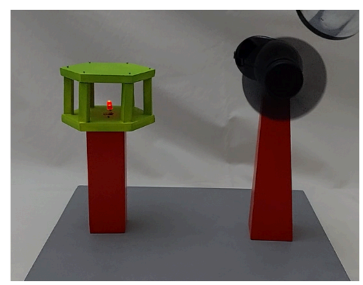
In another example, a wooden kitchen paper holder served as the base for the wind turbine. The DC motor was attached to the wooden stick using paper tape for stability. Long wires with crocodile clips were used to connect the 3V LED to the DC motor. When the wind turbine spins, the motor generates enough electricity to power the LED, lighting up the house. The model of the house in this example was created using thick cardboard from gift boxes. A hole was made in the back of the house to allow wires to pass through and connect the circuit.

8.3 Re-using components and playing with balsa wood towards a wind-powered lighthouse

In this example, the artefact relies upon the reuse of electrical components and other supplies. The propeller is from an old computer's power supply. A broken hand mixer was used to stabilize the motor whereupon the propeller was attached. Balsa wood was used for making more robust models (both for the lighthouse and the wind turbine base). Screws, small push pins, a small drill, and a silicone pistol were also used.

Post lesson follow up & summary

9. Discussion Topics

It is not a windy day. How can we continue working on the project and testing our solutions?

You can test out your wind generator using: a hair dryer, a fan or by blowing air. You can check how the power of the "wind" (real or artificially-generated) affects emitted light. This can be a great opportunity to raise discussion in the class and to encourage your students to document their findings/observations. What role does the power of the wind play? What is the role of the blades and the angle of the wind? Encourage your students to experiment and document their observations.

	Comments
	
	
	

Other ideas for generating wind capable of lighting up the led…….	

Do I need a resistor?

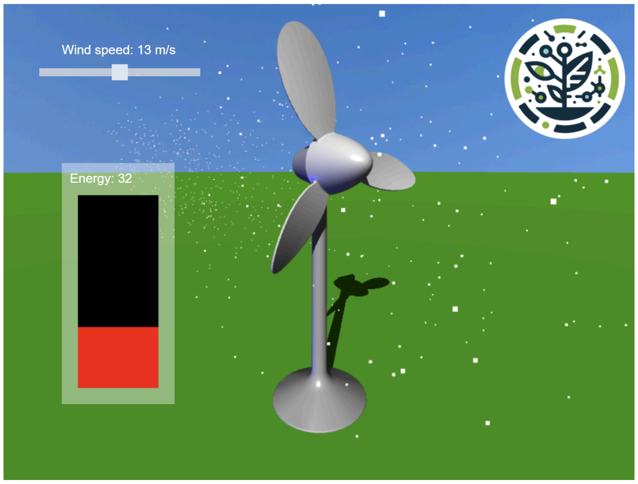
In this particular circuit, the voltage that is generated is low and the risk of damaging the LED is limited. However, you could encourage your students to connect a resistor (see diagram below) and observe how this affects the performance/functionality of the LED. Depending on the value of the resistor (measured in ohms), the LED may emit a dimmer light or not light up at all. Such an example can be an ideal learning opportunity to discuss the functionality of a resistor. Resistors of different values are available in the STEAM4CLIMATE toolkit.

Exploring relationships, digging into wind generators

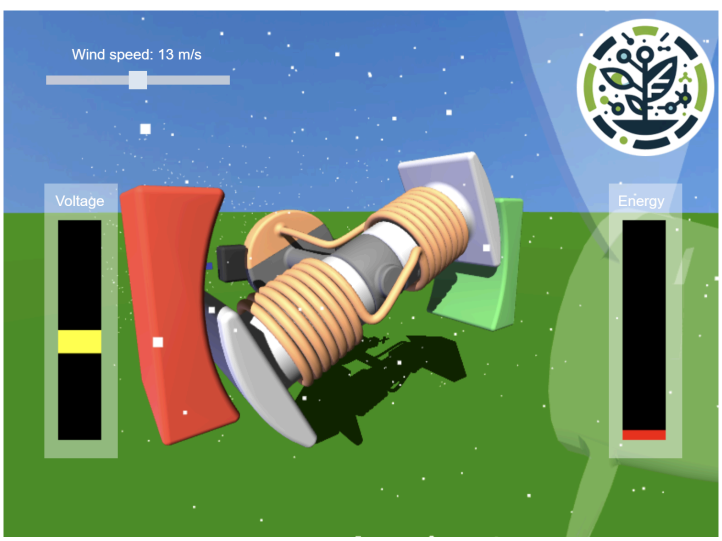
Check the interactive 3D model[3] that appears below or scan the relevant QR code and invite your students to discuss in teams the role wind speed plays in the wind generator's output.

Is it a linear relationship? Well, in fact the output is proportional to the cube of the wind speed.

[3] https://www.iludis.de/S4CExperiment/index.html



The next 3D model [4] (accessible also through QR code) sheds some light into how the kinetic energy of the wind produces power. This is the very principle of electromagnetic induction; a copper wire rotates inside a magnetic field and as a result voltage is being induced on the terminals of the coil. When this coil is connected to a load (e.g. a lamp) the load would be powered (lamp would be on). Why is the voltage wave crossing zero? How does the voltage wave change with wind speed?



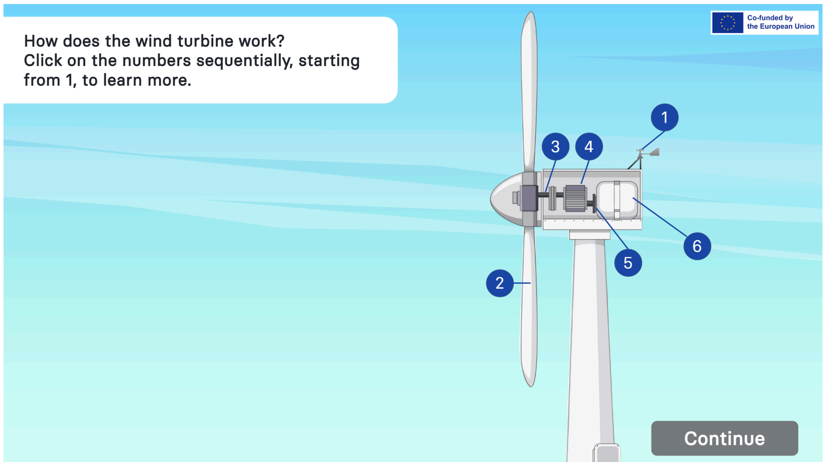
[4] https://www.iludis.de/S4CMotor/index.html

The voltage wave crosses zero because the induced voltage is alternating in nature. As the coil rotates, the direction of motion relative to the magnetic field changes, causing the voltage to reverse polarity periodically. This is why the voltage waveform alternates between positive and negative values, crossing zero at each cycle.

Scaling Up: Understanding Wind Turbines and Energy Storage

This project leads to a simple wind generator, which is a model for wind turbines used globally to generate electricity. Though they operate on a small-scale, they use the same physical principles to convert wind energy to electricity.

After completing the project, you can help your students expand their understanding by exploring the various components of a wind turbine, with a particular emphasis on energy storage. The following interactive element/animation[5] (accessible also through QR code) will guide this exploration and inspire thoughtful discussion around the following two questions: **How does the wind turbine work** and **how the produced electricity comes to our homes**?



[5] https://project-spaces.eu/learningcontent/steam4climate/scenario1/story.html

Climate change and Wind Energy

Interviews with experts (see below) can help students build a comprehensive understanding of how renewable energy sources, such as wind energy, play a crucial role in addressing the impacts of climate change. As we explore the benefits of wind energy, it is also important to consider the planning and placement of wind turbines. Thoughtful integration of these technologies can help safeguard biodiversity and protect local ecosystems, ensuring that our efforts to combat climate change are both effective and environmentally responsible.

STEAM4Climate Interviews - Electrical Engineer - Part 1/4 https://youtu.be/8nIPh5TgJFs	
STEAM4Climate Interviews - Electrical Engineer - Part 2/4 https://youtu.be/un3Q8wEW2qY	
STEAM4Climate Interviews - Electrical Engineer - Part 3/4 https://youtu.be/plbWdhO2vS8	

STEAM4Climate - Talk with an Electrical Engineer - part 4/4 https://youtu.be/S0qqVsj0mfg	
STEAM4Climate - Talk with a Power System Engineer https://youtu.be/1HkZFg0ikm8	

10. Extensions

This project offers plenty of opportunities for extension and deeper exploration beyond the initial activity. Teachers can encourage students to expand the circuit by connecting additional LEDs to investigate series and parallel connections, use a multimeter to measure voltage and study how wind intensity affects energy output, or design and test their own propellers to optimize performance. Students can also use an anemometer to measure wind speed and relate it to the generated electricity, deepening their understanding of the underlying principles. The activity can further be linked with a solar-powered house project to demonstrate hybrid renewable energy solutions.

For more ideas and additional resources to enrich or extend this project, visit https://project-spaces.eu/s4c/steam4climate-toolkit/steam4climate-toolkit-diy-wind-turbine/ or scan the QR code.