In collaboration with:

eawe european academy of wind energy

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WindEurope

TEACHERS' TOOLKIT

Learning wind energy in **primary schools**

MODULE 3

UNDERSTANDING WIND TURBINE TECHNOLOGY

OVERVIEW

By watching free video resources, students can learn more about the different components of a wind turbine and how they work. They will build their own wind turbines and test them to calculate the time it takes for a turbine to lift a 20g weight.

GRADES

- 5-6th Primary (10-12 yo)

TIME

- Two (50-minute) classes to work on the wind energy videos and a virtual tour of a wind turbine
- Four (50-minute) classes to build and test wind turbines

SUBJECTS

- Science/Technology
- Physics
- Grammar

LEARNING OBJECTIVES

At the end of this module, students will have acquired the following knowledge and competences:

Knowledge

- How a wind turbine works, and its different components
- Understand the lift and drag forces
- Understand the generation of energy from rotations

Competences

- To present mental images/representations in the form of drawings and text
- To draw information from a video documentary
- To take notes in the form of key words while watching a video
- To build a 3D object using recycled material

LESSON PLAN

MATERIALS

To build wind turbines in the classroom you will need:

- Small-scale wind turbines between 20 and 50 cm in height (e.g. Vestas or Siemens Gamesa)
- Plastic bottles measuring 1.5 or 2 litres + cups
- Sand to fill the plastic bottles to help stabilise them
- Cardboard or paper to make the blades
- Wooden sticks to hold the blades in place
- A cork to help fix the blades
- Sticky tape and instant glue
- Small generators equipped with a small LED bulb
- 20g weights
- A string to attach the 20g weight
- A fan

See the step-by-step guide to building a wind turbine with recycled material in Support Material for the Teacher

METHOD

STEP 1

Constructing an anemometer

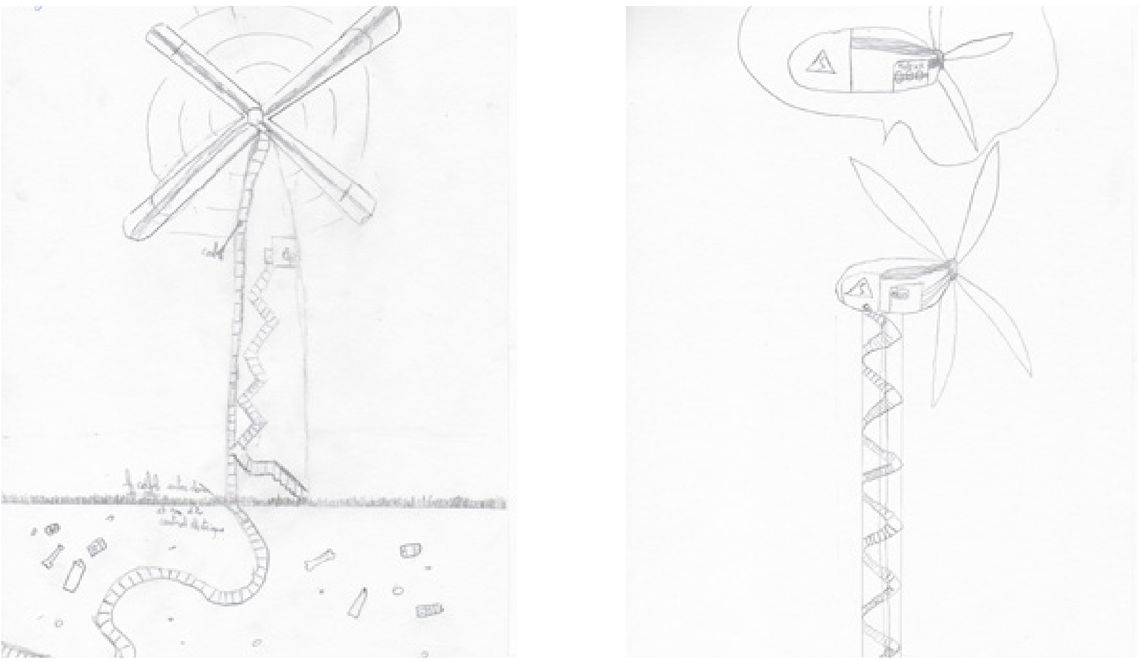
- Each student gives a written answer to the following three questions, presenting their thoughts (representations) about wind turbines and wind energy:
  - What do I know about wind turbines?
  - What would I like to learn about them?
  - Why is this topic relevant?

- Each student makes a diagram of a wind turbine and how it works based on what they already know/ imagine (fig. 14)

- Each student explains their diagram in the form of text

- This will serve as a starting point for the upcoming activities, when discussing how a wind turbine works

FIG. 14 & 15



Example of a student summary

Exterior of a wind turbine

1. BLADES

- Generally **three**
- **Aerodynamic** shape

2. NACELLE

- **Wind vane:** indicates wind direction
- **Anemometer:** measures wind strength
- **Lightning protection:** protects the wind turbine from lightning strikes

3. TOWER

- **80** metres tall

Interior of a wind turbine

4. NACELLE

- **Generator:** transforms wind energy into electricity
- **Yaw drive:** helps the blades to face the wind
- **Gearbox:** increases the rotation of the main shaft when there is not enough wind
- **Rotor axis**
- **Emergency brake:** stops the turbine when there is too much wind

Size of a modern wind turbine:

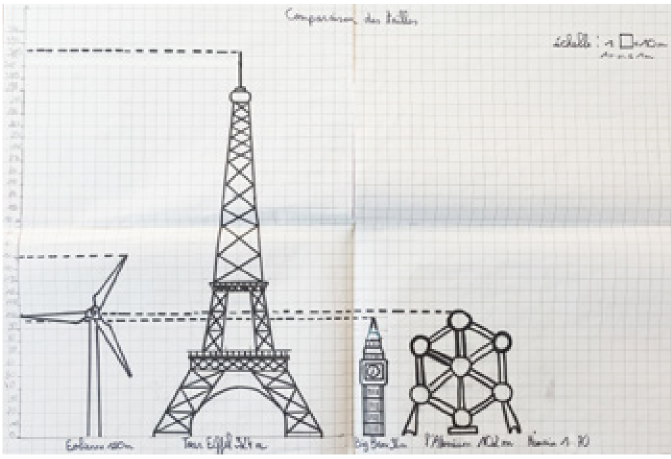


FIG. 16
Students calculate the height of a wind turbine Scale: 1 cm = 10 m.

Weight of a modern wind turbine:

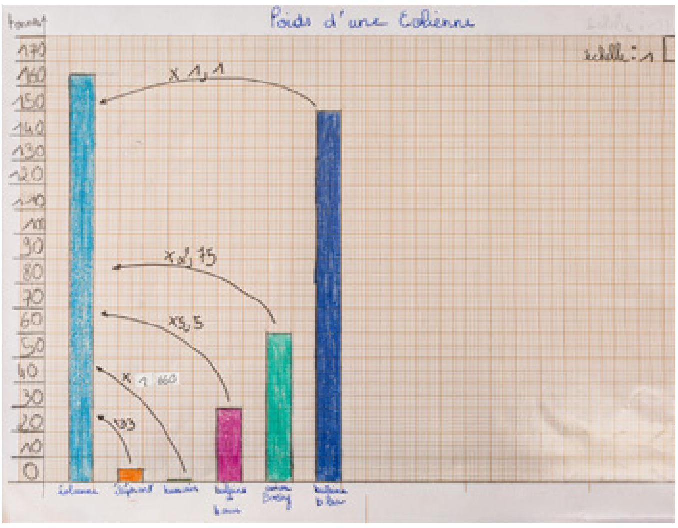


FIG. 17
Students calculate the weight of a wind turbine compared to an elephant, a human, a humpback whale, a Boeing plane and a blue whale. Scale: 1 cm = 10 tonnes.

STEP 2
Learning about how wind turbines work

- To start, all students in the class watch a video together to learn more about the different components of a wind turbine and how wind turbines work https://www.youtube.com/watch?v=gHUJqTT3THU&

- Students take notes while watching the video

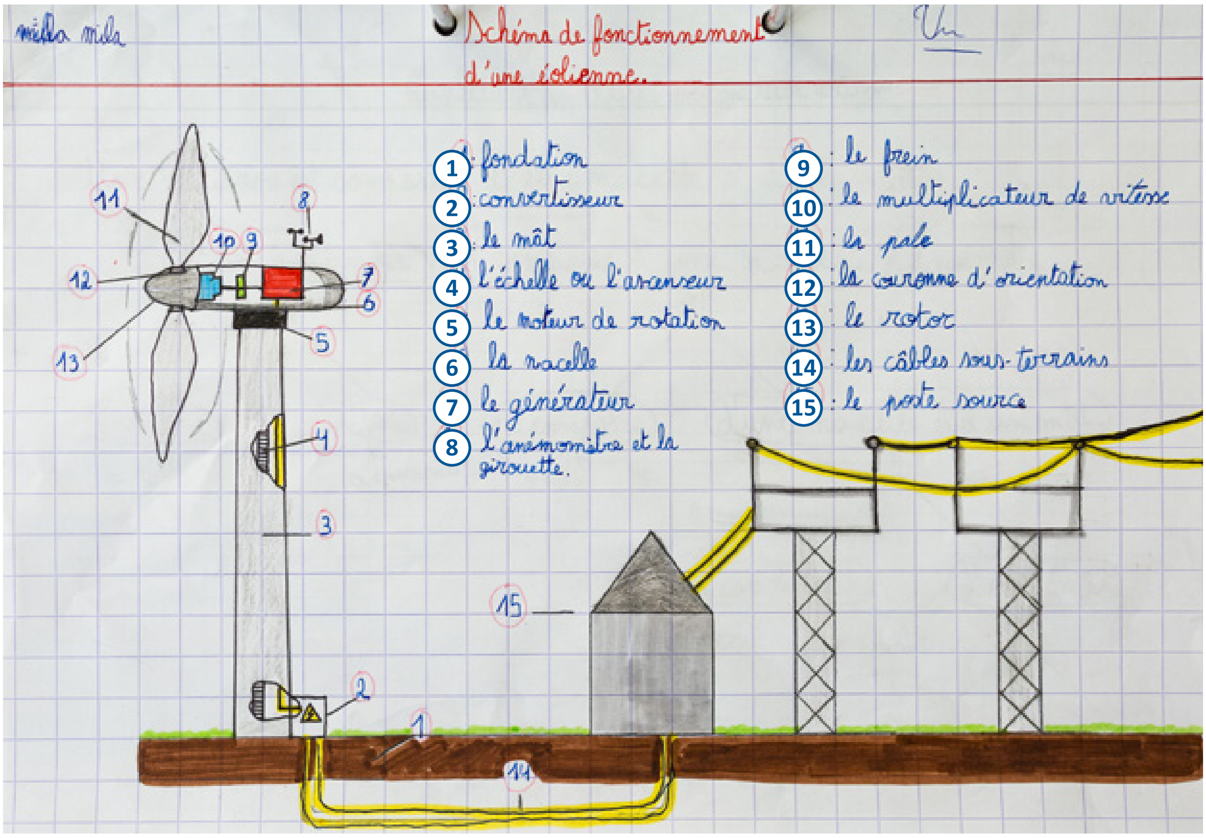
- They then study real small-scale wind turbines (20 to 50 cm tall, such as Vestas or Siemens Gamesa)

- With all this, they can make a summary describing (see previous page):
  - The exterior of a wind turbine
  - The interior of a wind turbine
  - The size of a modern wind turbine compared to other buildings they know.
  - The weight of a modern wind turbine

STEP 3
Making a final diagram of a wind turbine

Based on the summary of the notes from steps 1 and 2 students should work together on a diagram representing a wind turbine and its different components, like the example below:

FIG. 18



1. Foundation
2. Connection to the electricity grid
3. Tower
4. Access ladder or lift
5. Wind orientation control (Yaw control)
6. Nacelle
7. Generator
8. Anemometer and wind vane
9. Brake
10. Gearbox
11. Rotor blade
12. Blade pitch control
13. Rotor hub
14. Underground cables
15. Substation

STEP 4
Building a wind turbine

- To successfully build a wind turbine in the classroom, students should aim to complete the following challenge:
  - **Build a wind turbine with recycled material that can lift a 20g counterweight as quickly as possible** (using the step-by-step guide in the section Support Material For The Teacher below)
  - **Explanation of the challenge:** The spin of a wind turbine rotor comes from the aerodynamic interaction between the blades and the wind. During this interaction two forces are created: the lift force, which triggers the rotation, and the drag force which acts against the blade movement in the opposite direction, trying to decelerate it. The performance of a wind turbine with a given diameter (limited in this challenge to 30 cm) depends on the blade shape and the number of blades being used. To see which performs best, students do experiments with different blade geometries and different blade ranges
- Students are divided into groups of 4. They then select the material they will need and think about how to go about building their wind turbines. They should pay attention to the **orientation** of the blades, their **shape**, **size** and **material**
- Fill the bottles with sand to make them more stable, then attach the generator. Build wedges to link it to the bottle
- When the wind turbines are built, each group tests it using a fan to generate wind

Instructions on shape and orientation of the blades:

Different types of blades can be used in the class:

FIG. 19

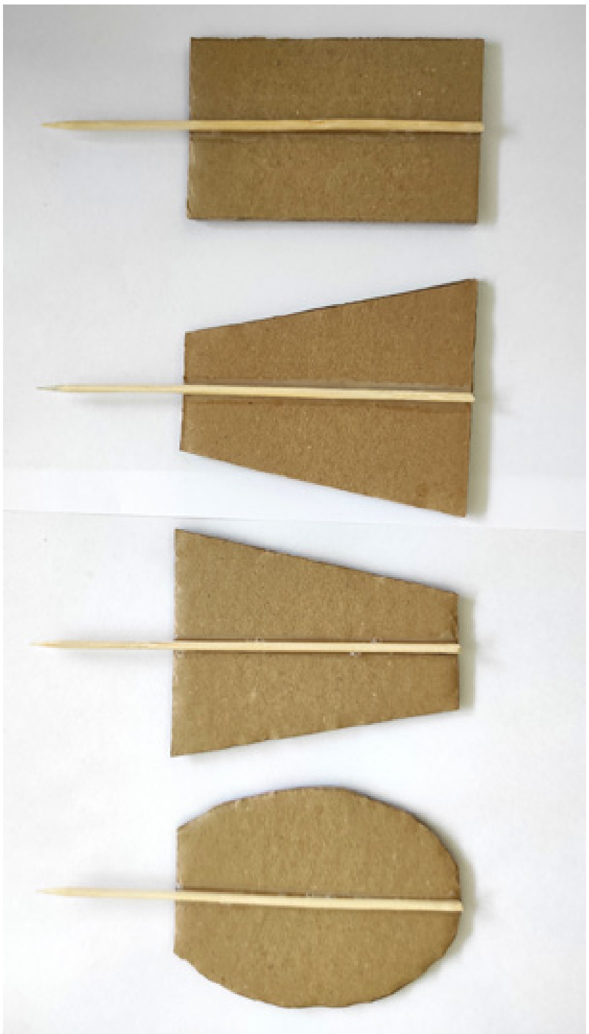


FIG. 20

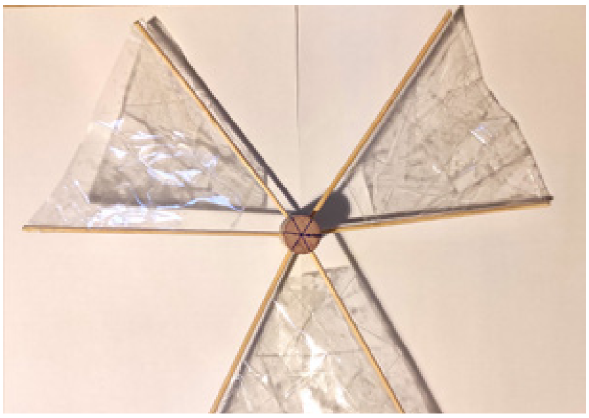


FIG. 21

The blades are set onto the hub so that they face the flow with maximum surface exposure. In this case the rotor will offer strong resistance. No lift force is created, and the rotor can't spin

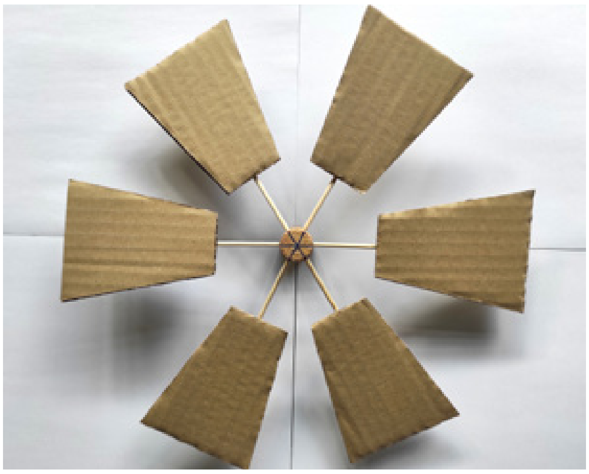


FIG. 22

The flow of the wind is axial (the wind blows from our location towards the rotor), the entire airflow will pass through the blades with almost no interaction at all. Once again, it won't rotate.

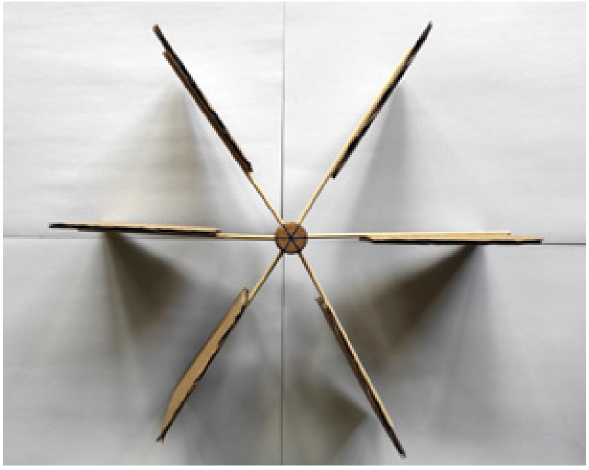
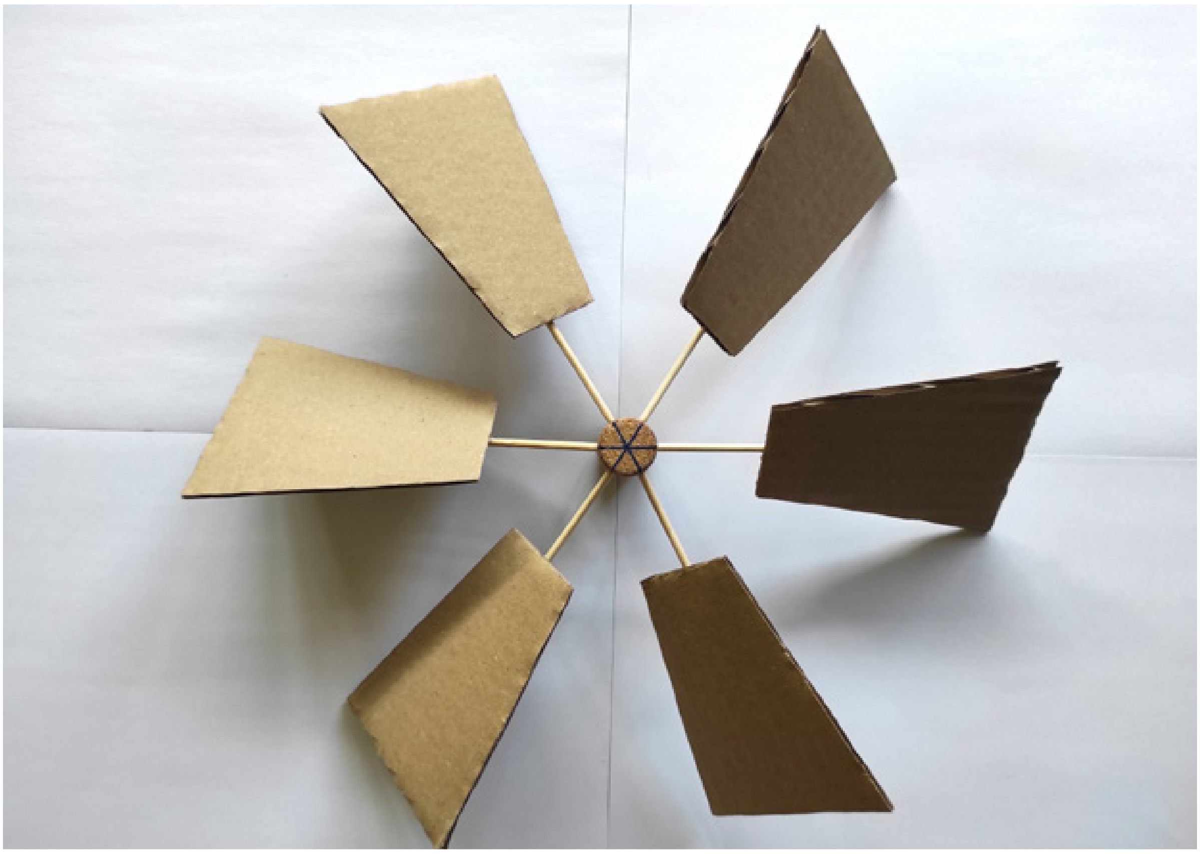


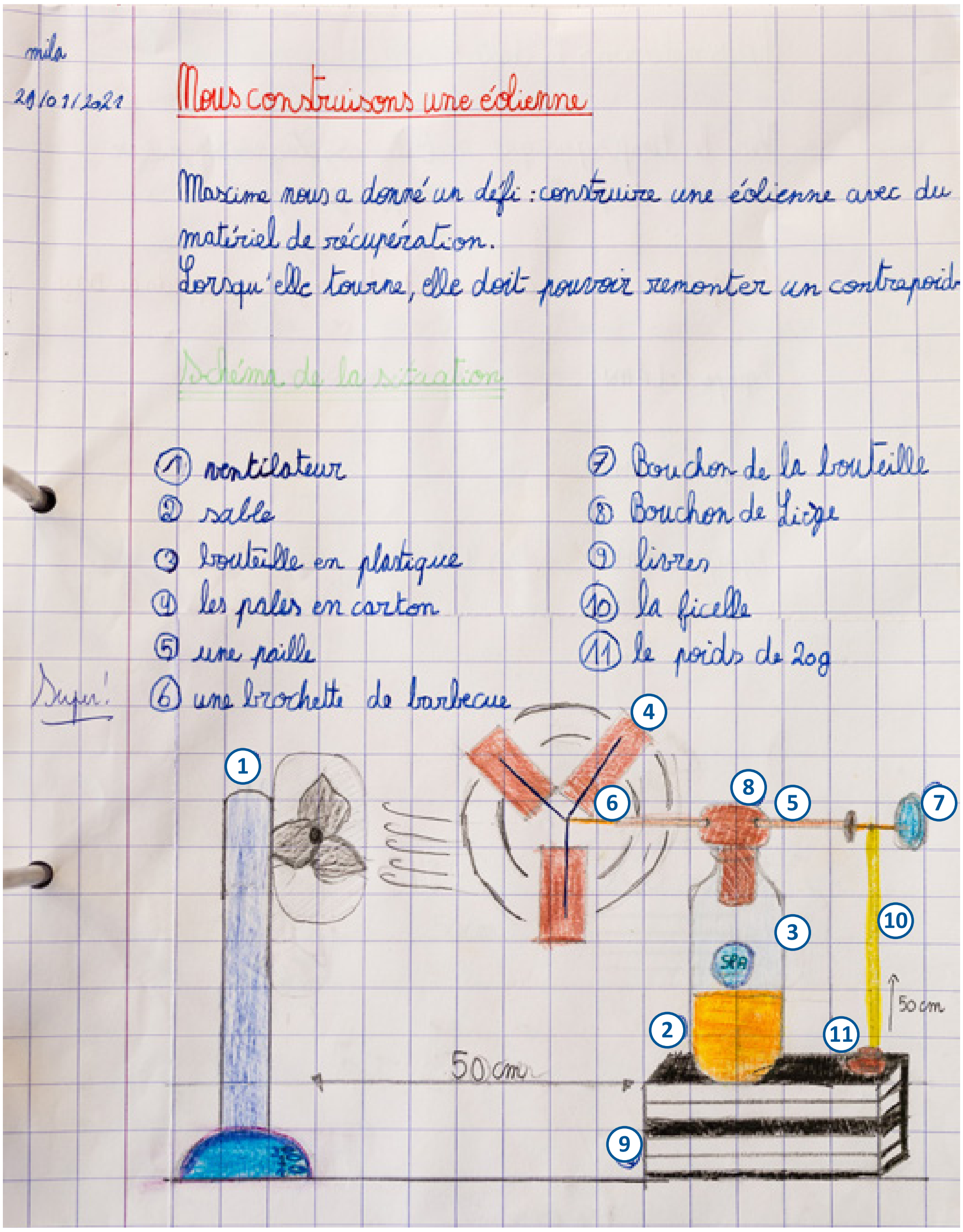
FIG. 23

When the blades are rotated at an angle of 45° degrees, there is a strong interaction between the oncoming wind and the blades. The flow passing through the blades creates a lift force that spins the rotor. We can also set angles other than 45° degrees to find the best angle (pitch) for our rotor design.



Building the wind turbines:

FIG. 24
Student drawing explaining the construction of the wind turbine and the challenge exercise.



1. Fan
2. Sand
3. Plastic bottle
4. Cardboard blades
5. Drinking straw
6. Barbecue skewer
7. Bottle cap
8. Cork
9. Books
10. String
11. 20g weight.

FIG. 25
Wind turbines built by the students

FIG. 26
Student with her wind turbine.

FIG. 27
Wind turbine made by a student at a scale of 1:100

The challenge;

When everyone is ready, the competition can get underway, one group at a time. The students should record the time it takes for their wind turbine to lift a 20g weight, using a table (see below).

TABLE 5

GROUP	TIME (SECONDS)
1	5.40
2	3.42
3	7.73
4	4.04

This challenge can also be carried out using a heavier counterweight.

STEP 5
Grammar lesson using the course vocabulary

To make the curriculum easier to understand, the teacher can use the subject of wind turbines indirectly to teach grammar. This could mean using sentences from the discussion as the basis/material for a grammar lesson.

Examples of sentences:

- On Tuesday, our class saw a video on wind turbines
- A wind turbine is made up of a nacelle and a tower

SUPPORT MATERIAL FOR THE TEACHER

This Toolkit offers support material for the teacher to help implement the curriculum. It was prepared by wind energy experts and is meant to inform the teacher about the subject area of each module. This will help the teacher to plan out his/her lesson and to help them pass on this knowledge to the students. Activities in this material should make use of recycled and affordable material.

The support material contains the following and can be downloaded here

Theoretical aspects

- The concept of energy, its types and forms
- The concept of aerodynamics, how it explains the shape of wind turbine blades and their interaction with wind
- The concept of air and atmospheric pressure
- The European Wind Atlas
- How do we measure wind?
- Basic components of a wind turbine

Classroom activities & experiments

- Forms of energy
- Energy transformation
- Atmospheric pressure and wind formation

Classroom discussions

- Renewable versus non-renewable sources of energy; their advantages and disadvantages

YouTube videos

- Virtual tours inside and outside a wind turbine

Step-by-step guides and instructions

- Building a cup anemometer and taking measurements
- Building a wind turbine and making it spin
- Making a wind vane and finding the wind direction

To find out more you can use the following resources:

School resources:

- Wind with Miller
- Alliant Energy Kids
- Energy student resources
- NEED Curriculum Resources
- Wind for Schools

WindEurope LearnWind free resources:

- **Let the wind blow** book & video
  Explains climate change & wind energy

- **When I Grow up** book
  Inspires young adults to consider a career in clean energy

- **Wind Energy Basics** animation
  Teaches users about wind energy technology

- **Offshore Wind 4 Kids** workshops
  Demonstrates how offshore wind turbines work

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If you are interested in distributing or translating this Toolkit, contact yamina.guidoum@windeurope.org

If you are a teacher implementing this plan in your school, we would be happy to receive your feedback at yamina.guidoum@windeurope.org.

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