

Tasks

Model 3/4/5 – Wind turbine / Wind energy

Construction task Model 3

Build model 3 according to the instructions. Observe the following points while building:

- The shaft of the windmill should move smoothly so that the belt (O-ring) on the transmission wheel can transmit the rotational movement to the drive wheel of the solar motor.
- The black cable of the solar motor generator is connected to the input jack on the LED marked with a + (plus pole).
- The LED is only designed to show how the solar motor can be used to generate electricity. It may be operated with a maximum of 2 V direct current. Higher voltages will immediately destroy it.

In a wind power plant, the kinetic energy of the air (wind power) is converted into electrical energy.

The blades of modern wind turbines are called rotor blades, and are held together by a rotor hub. The rotor hub and rotor blades make up the rotor. The rotor is at the start of the functional chain of a wind power plant. It is attached to a shaft, and the rotation of the shaft is used to drive a generator that converts the rotational energy into electrical current.

We differentiate wind power plants based on their rotational axes. We differentiate between horizontal and vertical rotational axes.

In our model with a horizontal axis, the rotor actuated by the wind transmits its rotational energy to the transmission wheel. The rotational movement of the transmission wheel is then transmitted to the drive wheel of the solar motor via a round belt (O-ring) This type of drive is called a belt drive. This type of drive is not used in modern wind power plants (see model 5 – Wind turbine).

The design principle is similar to a typical windmill or sawmill. Actually, after electricity was discovered and the generator was invented, the first attempts to generate electricity with wind power were based on the concept of a windmill. Instead of converting the kinetic energy of the wind into mechanical energy, a generator was used to generate electrical energy. As fluid mechanics were developed over time, the structures and blade shapes also became more specialised. Modern windmills are much larger, and have a rotor diameter of approx. 90 to 126 meters.

The solar motor here acts as a generator and converts the rotational energy into electrical energy, causing the LED to light up.

Topic task

1. A wind turbine only starts to turn when there is a high enough wind speed. This is called the start-up wind speed. In contrast to models 4 and 5, model 3 is designed for strong wind. Hold a tabletop fan or powerful hair dryer in front of the rotor, first holding it far away. Then reduce the distance until the rotor blades begin to turn. Note the distance so that you can compare it to model 4 later. Alternatively, you can also keep the distance the same. In this case, note the setting at which the blades begin to turn. What other factors in addition to wind speed can influence the effectiveness of our windmill (with even rotor blades)? A little tip: Experimental tasks 1 and 2 will help you answer the question.
2. To assess the economic efficiency of a wind turbine, you must calculate its performance. How is the performance of a wind turbine calculated?
3. How many households can a 3 megawatt wind turbine supply that reached full load hours in 2000? A 4-person household uses an average of 3,500 kilowatt hours per year.
4. The energy a wind turbine can generate depends on the wind strength. What could help us decide to set up a wind turbine?
5. There are advantages and disadvantages to wind power as well. Which ones can you name?

Experimental task 1

1. During the experiment for model 1, the manual generator, you already discovered that an LED requires a minimum level of voltage to light up. Our windmill would have to turn very fast to generate this voltage. However, our windmill continues to generate energy even at a slower rotational speed. Measure the voltage on the generator at different distances from the fan, and note the results so that you can compare them later on with model 4. What conclusions can you already draw?
2. Shorten the rotor blades by removing the green plates, then compare the measured voltage values with those from the previous experiment. Do these results confirm your hypothesis from topic task 1?

Construction task Model 4

Build model 4 according to the instructions. Observe the following points while building:

- The shaft of the windmill should move smoothly so that the belt (O-ring) on the transmission wheel can transmit the rotational movement to the drive wheel of the solar motor.
- The black cable (with green flat plug) of the solar motor generator is connected to the input jack on the LED marked with a + (plus pole).
- The LED is only designed to show how the solar motor can be used to generate electricity. It may be operated with a maximum of 2 V direct current. Higher voltages will immediately destroy it.

There are two basic types of wind turbines. Those with a horizontal rotational axis (model 3) and those with a vertical rotational axis.

The oldest, most well-known wind power plants in the world are the vertical wind power plants that have been built since 1700 B.C. The major difference is that they are independent from the direction of the wind.

Over the centuries, inventors and engineers have worked to continuously improve the effectiveness of windmills. While the initial models were still built with flat blades, ongoing scientific discoveries on fluid mechanics (the understanding of the movements of fluid and gaseous media) resulted in new rotor designs (Savonius rotor, Darrieus rotor).

Experimental task 2

1. Our model also allows you to experiment with basic flow behaviour phenomena. Hold a hair dryer or fan in front of the rotor blades - first directly in front, then offset to the side. What conclusions can you draw from your observations, and why is this the case?
2. Now compare your results on start-up speed from model 3 with this model, and measure the voltage at different distances. What can you determine?

Construction task Model 5

Build model 5 according to the instructions. Observe the following points while building:

- The red cable of the solar motor generator is connected to the input jack on the LED marked with a + (plus pole).
- The LED is only designed to show how the solar motor can be used to generate electricity. It may be operated with a maximum of 2 V direct current. Higher voltages will immediately destroy it.

This model is closest to the design of a modern wind turbine. The aerodynamic properties of the rotor directly determine how much wind energy can be converted into mechanical work.

Experimental task 3

1. Now compare your results on start-up speed from model 3 and 4 with this model 5, and measure the voltage at different distances from your wind source. What can you determine?