How do wind turbines work?

Windmills have been assisting mankind to ..... (zamienić) the energy contained in wind to many other useful forms for the last two thousand years. Today's wind turbines are capable of converting a great amount of energy in the wind into electricity. This is due to the ..... (łopaty) which are developed using state-of-the-art aerodynamic analysis and the other performance-enhancing ..... (urządzenie). In this video we will explore these different set of technology in a sample yet scientific way.

First, let's get into its basic working. If the blowing wind can turn the ..... (skrzydło), we will receive electricity from the generator that is attached to it. However, how does the blowing wind turn the wing? Let's have a close look at the blade. The blade has a lot of airfoil (*pl. płat*) cross-sections (*pl. przekroje)* consisting of different size and ..... (kształty) from the root to tip. The simple airfoil technology makes the wind turbine blade turn. That means that a lift force is produced when a fluid moves over an airfoil. This way the wind turbine achieves the basic ..... (obrót) we are accustomed to seeing. Just as in a moving train you experience things relatively, the moving wind turbine blade also experiences the wind relatively. For the moving blade the relative wind velocity is as shown. Therefore the wind turbine blade is positioned in a tilted manner in order to align *(pl. ustawić w linii)* with the relative wind speed. As the blade velocity increases to the tip the relative wind speed becomes more inclined towards the tip. This means that a continuous twist is given to the blade from the root to tip. However this rotation cannot be directly coupled to a generator. Because the wind turbine blades typically turn at a very low rate of rpm due to the issues of the ..... (hałas) and mechanical strength. Considering this low-speed rotation we cannot produce any meaningful electricity frequency from generator. So before connecting to the generator the speed is increased in a gearbox. The gearbox uses a planetary gear set arrangement to achieve the high speed ratio. A ..... (hamulec) also sits in the nacelle. The function of the brake is to arrest wind blade rotation during excessively windy conditions. Consequently the electricity that is produced, passed through the cables towards the base, where a step-up transformer is situated. The wind turbine should face the wind normally for maximum power extraction. But the wind direction can change at any time. A velocity ..... (czujnik) on the top of the nacelle measures the wind speed and direction. The deviation in the wind's direction is sent to an electronic controller which in turn sends an appropriate signal to the yawing mechanism to correct the error. You can see how the yaw motors turn the ..... (gondola). Thus the wind turbine will always be aligned with the wind direction. According to the wind speed the relative velocity angle of the wind also changes. A blade tilting mechanism tilts the blades and guarantees a proper alignment of the blade with the relative velocity. Thus the blade are always at the optimum angle of attack with the relative wind flow. Efficiency of the wind turbine is the really interesting topic. To gain a good insight into wind turbine efficiency assume that you are measuring wind speed at upstream (*przeciwprąd*) and downstream (*współprąd*) over wind turbine. You can note that the wind speed at the downstream is much smaller than the upstream This is because the blades absorb some kinetic energy from the wind. The same amount of energy is converted as mechanical power of

the wind turbine. It is interesting to note that a wind turbine absorbs 100 percent of the available kinetic energy only if the downstream wind speed becomes zero. However zero wind speed at downstream is a physically impossible condition. This cartoon animation clearly depicts this fact. Zero downstream speed simply means the whole flow is stock. This physical reality of the flow demands a certain amount of exit wind speed. That means that there is theoretically maximum efficiency a wind turbine can achieve. This limit is known as Betz's limit. Essentially it means that no wind turbine in the world can ever cross the efficiency limit of 59,3% (0,593).

źródło: https://www.youtube.com/watch?v=qSWm_nprfqE

Zad. 1. Uzupełnij tekst wpisując w luki słowo po angielsku.

Zad. 2. Uzupełnij tabelę, wpisując słowo odpowiednio po angielsko lub po polsku.

piasta	
	blades
gondola	
	tower
fundament	
	brake
nasada/ rdzeń łopaty	root of blade
końcówka łopaty	tip of blade
przepływ	
	airfoil

prędkość wyłączenia	
	cut-on speed
mierzyć	
	yawing mechanism
nachylać	
	lift force
kierunek wiatru	
	windy conditions
przekroje	
	velocity sensor

Zad. 3. Wyjaśnij na czym polega ograniczenie / prawo Betza?

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