

Information on specific types of devices, their standard performance and sizes refer to the regulatory and technical documents. Typically, this document is technical specification (TS) of the plant. In some cases, in order to unify the products having wide application and manufactured at different plants, the document level increases (sometimes to the level of the State Standard).

### Conclusion

In conclusion, I would like to say that the circuit breakers play a huge role in the electric power industry. This device is very important in our lives, so it protects the electrical network from short circuits and from various emergency conditions. Accidents can occur everywhere, such as in homes so industrial facilities.

### References:

1. <http://electronics.howstuffworks.com/circuit-breaker.htm>.
2. <http://electralschool.info/spravochnik/apparaty/23-avtomaticheskie-vykljuchateli.html>.
3. [http://en.wikipedia.org/wiki/Circuit\\_breaker](http://en.wikipedia.org/wiki/Circuit_breaker).

**Gordinski, E.I., Balastov, A.V.**

### Wind power benefits

*National Research Tomsk Polytechnic University*

I've read in the Internet, that [1]"Canadian company Magenn Power tried the unusual type of the generator in the form of the revolving dirigible, which is able to get the wind from the big height. Flying wind-turbine is called MARS(Magenn Power Air Rotor System). Under the influence of the air stream its balloon revolves on its horizontal axis, to which generators are attached, and ropes, maintaining the dirigible at the one place and conveying the received electricity to the ground." I was interested, in what condition is the energetic problem nowadays and what is its solution. This is how the theme of my project "Wind power benefits" arose.

Practical part:

- 1) To make a calculation of the capacities of the ideal model of the wind-powered generator.
- 2) To make a calculation of the capacities of the ideal model of the wind-powered generator with all the losses.
- 3) To define the coefficient of the efficiency of the wind-powered generator and make a calculation of money saving depending on the number of windy days.
- 4) Make a conclusion about a rationality of the usage of the wind-powered generator.

There is a serious problem how to provide enough quantity of the electric power, fuel and raw materials. Fuel and energy resources constantly run out and in some hundreds years can totally disappear.

The principle part of energy, being consumed by mankind, we get from black coal, oil and gas, i.e. from materials which are called fossil fuel. This type of energy is called non-renewable energy because it cannot be used twice. Fossil fuel cause pollution of the environment, and, more than that, its reserves are limited. However, people's necessity in energy is so high that they continue to use this type of fuel.

In contrast to fossil fuel there are sources of renewable energy like water, wind, sun, inside warmth of the Earth. Although from the diagram we can see that only 4 % of the renewable energy is used, its reserves are unlimited.

Renewable energy causes less harm to the environment than non-renewable one, but nowadays it still cannot meet people's electricity demand. This type of energy is also called alternative energy, maybe because in the future the major part of our power inputs will fall to the share of alternative energy. In 2011 the total fixed capacities of all the wind-powered generators made up 237.227 megawatt.

[2 c.2]“International Energy Agency has worked out the scenarios of structural changing of the sources of raw materials' consuming for energy production to 2050. There are 2 of them: ACT Map (the first one), BLUE Map (the second one).

According to the first scenario of developing (ACT Map), the part of major types of the energetic raw materials (oil, black coal) in 2050 will reduce to the minimum, besides the altered gasified coal presents a considerable part – 15 %, the part of oil will reduce, the part of gas and casing-head gas increases. Renewable sources of energy can present 35% from the aggregate volume of electricity generation.

According to the second scenario of developing (BLUE Map), common energetic coal and oil will be out of use to 2050, the part of gas will diminish to 6-7 %, altered gasified coal makes up a considerable part – 15 % and nuclear power engineering – 24 %. Renewable energy sources can make up 46 % from the aggregate volume of the electricity generation.”

Wind as an energy source has been attracting mankind for a long time. Seeing what destructions can bring storms and hurricanes people started to think about the usage of the wind energy. For a lot of centuries people could use free and ecologically clean wind energy. Egyptians had been swimming under sail 2500 years before AD, using wind energy, filling sail of barks and ships.

The other example of the wind force usage are windmills. For ages people used the mechanical force of the wind, trying to facilitate their labour. Persians in VII century BC used this energy for field irrigation and grinding of grains. Not without reason people say: “Feeling the wind, a fool puts a shield from it, but a wise man puts a windmill. Windmills, generating electricity, were invented in 19 century in Denmark. In 1890 the first wind power station was built there, and to 1908 there were 72 stations with capacities from 5 to 25 kilowatt. The biggest of them had the height of the tower of 24 metres and 4-fanned rotors over 23 metres in diameter.

«We make money from the wind!» – says one of the German companies producing wind power stations. And this is especially true, because wind turbines generate energy from the air, and the energy is money, and not small at that.

I understand that we live in such a zone where the usage of such type of energy is not very reasonable, but is possible on a small scale. For example, you can try to use it on a garden plot.

[3]”In Russia at the beginning of the XXth century N. E. Jukovskiy worked out a theory of the wind engine. In Germany at the same time with Jukovskiy in 1919 the physicist Albert Betz discovered a law which defines the maximal energy, which could be got from the wind-powered generator. According to this law, a wind-powered generator can generate more than 59,3 % of kinetic energy of the wind.

The law of Betz means that wind turbine will never have bigger coefficient of efficiency than 59,3 %. This law can be explained considering that if all the energy, being received from the motion of the wind in turbine was transformed into useful energy, than the speed of

the wind will consequently be equal to zero. But if the wind stopped on going out of the turbine, than the fresh wind won't get into turbine – the turbine would be blocked. For the wind to continue its movement through turbine and to generate energy, some movement in the turbine itself is needed. I.e. there should be some limit of the efficiency of the wind turbine – Betz law, which is equal to 59,3 %.”.

Wind-powered installation is a device for the transforming of kinetic energy into other types of energy. The particular thing would be a wind-powered generator which transforms kinetic energy of the wind into electricity.

**The calculation of the capacities for the model of the wind-powered installation**

$$P = \frac{\rho s v^3}{2} - \text{deduced formula from the formula: } E = \frac{m v^2}{2} \text{ и } P = \frac{E}{t}$$

$$S = \pi * R^2 - \text{rotor-swept area ( m2 ).}$$

$\rho$ - air density (1,29 kg/m3);

$$v\text{-defined experimentally: } v = \frac{s}{t} = 0,6 \text{ m/c.}$$

Representing all the calculations we get  $P = 6 * 10^{-4} \text{ W}$ .

**[4]”The calculation of the capacities generated by the full-size wind-powered generator.**

On the basis of this data I made a calculation of the capacities generated by the wind-powered installation in the ideal conditions.

Calculation formula:

$$Pu. = 0.5 * Q * S * V^3 .$$

P – capacities (watt);

Q – air density (1,29 kg/m3);

S – rotor-swept area ( m2 );

V – airspeed (mps).

Rotor-swept area for the 4-wing wind wheel I’ve found with the formula:

$$S = L * h * n .$$

S – rotor-swept area (m2).

h – height of the one cavity (m).

n – the number of cavities.

$$\cdot \quad L = \pi R \quad L = 3.14 m$$

$$\cdot \quad S = 3.14 * 2 * 4 = 25.12 m^2$$

$$\cdot \quad Pu. = 0.5 * 1.29 * 25.12 * 4^3 = 1037 W$$

As 100% transforming of one type of energy into another is impossible, than we should exclude losses. Wind wheel has certain CPU usage of the wind energy. The maximal significance of theoretical usage of wind energy belongs to ideal high-speed vaned wind wheels and is equal to 0,593. For the best examples of high-speed wind wheels with aerodynamical profile this index is equal to 0,42-0,46. For multiblade low-speed wind wheels this index is fluctuating from 0,27 to 0,35 depending on the quality of carrying out and is marked with the symbol Cp in calculations. For the reconciling of the turns of low-speed wind wheel and generator it is necessary to use a speeder. The coefficient of efficiency of the speeder fluctuates from 0,7 to 0,9 depending on the coefficient of transferring and carrying out. Transforming mechanical energy into electrical one we also have losses. That’s why we express it in the coefficient of efficiency of the generator Ng from 0,6 (for motor and tractor genera-

tors with an energizing coil) to 0,8 (for the generators with driving from permanent magnets).

$$P = 0.5 * Q * S * V^3 * C_p * N_g * N_b .$$

P – capacities (watt).

Q – air density (1,29 kg/m<sup>3</sup>);

S – rotor-swept area ( m<sup>2</sup> );

V – airspeed (mps);

CP – the coefficient of the using of the wind energy (0,35);

Ng – the coefficient of the efficiency of the generator (0,8);

Nb – the coefficient of the efficiency of the speeder (0,9).”.

$$P = 0.5 * 1.29 * 25.12 * 4^3 * 0.35 * 0.8 * 0.9 = 261W \approx 0.261kW$$

#### The calculation of the coefficient of efficiency for the full-sized wind-powered generator

$\eta = \frac{P}{P_u}$  –the formula of the calculation of the coefficient of efficiency for the full-sized wind-powered generator.

*P* –capacity with all mechanical losses.

*P<sub>u</sub>* –the capacity generated by the common wind-powered generator in the ideal conditions.

$\eta = \frac{261}{1037} = 0,25 = 25\%$  – the coefficient of efficiency of the wind-powered generator including all the losses.

The low index of the coefficient of efficiency can be increased if to use a wind-powered generator with high tower and long blades to increase the swept area.

[5]“Depending on the number of windy days a year and wind speed 3, 8 mps the capacity of the wind-powered generator:

$$181 \text{ days.} \quad P = 2815kW * h$$

$$275 \text{ days.} \quad P = 4277kW * h$$

In conclusion I want to say, that if consumed capacity is less than the one which is generated by the cheapest installation, than the installation of the generator won't be very expensive, and what is more, its cover of expenditure will go much faster. The lifespan of the generator is 20 years, also the service of the installation is required. Reasonable usage of the wind-powered generator is possible in the plant or in the area where there are no power lines.”

In my situation it is necessary to acquire a wind-powered installation costing 3000 \$ to get enough generated capacity. Its cover of expenditure will take 10-15 years.. Also it is absolutely unprofitable to buy a wind-powered generator if near there are power lines.

#### References:

1. <http://www.mechanicalengineeringblog.com/tag/magenn-power-air-rotor-system/>.
2. [http://www.iea.org/media/etp/translations/ETP\\_2008\\_Exec\\_Sum\\_russian.pdf](http://www.iea.org/media/etp/translations/ETP_2008_Exec_Sum_russian.pdf).
3. <http://vetryaky.ru/teoriya-idealnogo-vetryaka/>.
4. <http://www.vetrogenerator.ru/index.html>.
5. <http://vetrogenerator.org.ua/resheniya/dlya-chastnyx-klientov/>.