An efficient use of renewable wind energy toward a sustainable society

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We use electricity every day, but we seldom care about where this electricity comes from and how it is generated. In Japan, electricity is generated mainly using fossil fuels, such as fuel oil and natural gas. This generation process releases a lot of carbon dioxide (CO_2) into the atmosphere and causes global warming, which is one of the biggest problems in the world today.

To avoid using fossil fuels, it has been promoted to use renewable energies, such as solar, hydroelectric, and wind power. Renewable energy is energy sources that will not be run out semi-permanently, mainly obtained from natural environment. Renewable energies exist everywhere around us in the shape of heat or motion of something and they will never be exhausted. It will have little damage on the earth environment to use them as energy sources needed in human activities. These are the reason renewable energies have been promoted these days and they are expected to be a powerful means to realize the sustainable society.

Renewable energies are also beneficial from the perspective of energy self-sufficiency. Especially in Japan, we rely for the sources of energy on foreign countries and the energy self-sufficiency rate was only 12.1% in 2019[1]. That means almost 90%

of the energy consumed in Japan comes from overseas. It is a bad situation as it costs in money and energy to carry energy sources. If we can produce energy by ourselves, we can save the cost and energy to ship the sources from overseas. Renewable energies are of course accessible everywhere including Japan and it will help to increase the energy self-sufficiency rate and to save shipping energy cost.

However, because their energy density is generally small, it is difficult to obtain enough amount of electricity from renewable energy sources. Due to their low energy density, we need more area to obtain enough energy from renewable sources than from traditional sources like fossil fuels. To use renewable energies as the main source of energy in the society, it is necessary for now to build a lot of or large-scale generators. One possibility to solve this problem is to raise power generation efficiency. If we can obtain large amount of electricity from a certain amount of natural energy, the number of and the size of the power generation plant can be reduced. We want to generate as much electricity as possible from the natural energy.

An innovative technique has been developed at Tohoku University to enhance the power generation efficiency in wind power generation[1]. In wind power generation, the rotation speed of the propeller is generally controlled in order not to be too fast. When the propeller rotates faster than some optimal speed, the obtained electric power will be reduced from that in the optimal case. In other words, the output electricity should be limited to some value even though the wind gets strong and its power becomes large. This means that the conventional wind power generators do not make full use of the available wind power.

The researchers at Tohoku University have developed a new method to obtain energy as electricity also from the brake mechanism of the propeller which is essential to control the propeller speed. They introduced liquid metal, a kind of alloy, into the space between the propeller and the axis of rotation at the central part of the propeller control system, and applied magnetic field to that region. When the propeller rotates, the liquid metal moves with the propeller. When the metal moves in the magnetic field, electric current is induced arbitrarily in accordance with the law of electromagnetic induction. By adjusting a parameter of the circuit linked to the liquid metal according to the rotation speed of the propeller, the researchers can achieve a large electric power from this mechanism.

Also, the current in the liquid metal and the applied magnetic field generate the force to stop the propeller. It is called Lorentz force. By adjusting a circuit parameter and the strength of the applied magnetic field simultaneously, the researchers succeeded in controlling the strength of the Lorentz force, and therefore, controlling the propeller speed while obtaining sufficient electric output. The obtained electric energy is a part of wind energy that has been discarded in the conventional brake system. They connected the dynamics of the propeller and the electromagnetism to utilize the wind energy efficiently.

Their method will make wind power generation more efficient in near future. In addition, it may be applied to other power generation methods that have a rotating axis in their power generation mechanism. The new method has a potential to enhance the efficiency in various power generations. This will increase the proportion of renewable

energy in power generation, which leads to high energy self-sufficiency and decrease in the use of fossil fuels, and eventually contribute to stopping global warming.

Reference

[1] Ministry of economy, trade and industry, FY2019 Energy Supply and Demand Report (2021)

[2] Takana and Tanida, Mechanical Engineering Journal, Vol.4, No.1 (2017)