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The Role of Drones in the Electricity Sector

Similarly to the separation and development of electricity systems, the golden age of aviation dates back to the last century. Admittedly, in the beginning, the two technologies did not have much effect on each other; however, in the 21st century, these two systems in many cases cross each other's paths in everyday life, while performing the operation and maintenance tasks.

In this paper, the author describes how a modern electricity infrastructure is built up and explains the process used for transferring electric power generated by the power plants to the consumers. In addition, this paper familiarises the reader with the procedures and methods allowing to assign more and more functions and tasks to the drone technology and to assure its efficient integration with certain elements of the energy system.

Keywords: *drone, electric power, power plant, electric power distribution, power grid, safety*

1. Introduction

In terms of the past century, the primary elements of electricity systems – power plants and energy transmission systems – were not yet separated from each other and were treated as a unified whole. Such an approach had prevailed until World War I, when the need for energy electricity supply system began bringing up to the surface an issue that arises in case of all operating systems, i.e. continuous system monitoring, maintenance and repair. Nowadays, engineering and technology have reached a high level allowing to carry out these work processes economically, quickly, efficiently and safely with the availability of state-of-the-art tools.

As the "drone technology" – in addition to the military use – offers numerous possibilities for using drones in industrial, agricultural and commercial applications, devices mounted on the carrier platform (motion-picture camera, camera, parcel delivery, heat sensor, infrared camera, GPS transmitter, Bluetooth, Wi-Fi transmitter, motion detection, face recognition, biometric scanners, etc.), due to their modular layout, can be configured for the performance of any task and can be used extremely efficiently and quickly.

2. Infrastructure of the electricity supply system

Primary assets required for the operation of electricity supply systems can be divided into three main areas assuring the transfer of energy to the consumers. These assets are none other than power plants generating electricity, substations involved in the electrical power distribution and the energy transmission network responsible for electricity transmission.

1.1. Electricity generation

The greater part of electricity available to the user is generated in power plants by means of converting kinetic energy received from some thermal cycle into the electric power with the use of generators. The generated thermal power can come from the use of various sources like nuclear or conventional fossil fuels (coal, natural gas, oil) or renewables (biomass, biogas). Today, electricity generated with the use of solar and wind energy accounts only for a small part in the total amount of electricity production in Hungary; however, the efficiency and spread of these technologies is going at a high pace due to the applied energy conversion technology. In case of solar and wind energy, there is no intermediate stage of thermal energy production and conversion. In terms of the operation cycle, power plants can be basic power stations, dispatchable stations and power plants for peak-load operation; these three main types are supplemented by the renewables.

- The most important feature of basic power plants is their ability to maintain a constant load over time by means of continuous operation. Power stations, for example, nuclear power plants using modern technology and generating electricity at a low production cost are best applicable for this purpose.
- The primary task of dispatchable stations is to follow changes in the daily demand for electricity. The key requirement for performing this task is the ability to flexibly serve the wide range of consumer needs. This type comprises power plants operating on the basis of fossil fuels and carbon-emitting renewable power plants.
- The basic task of power plants for peak-load operation is to cover the daily peak consumption and to manage the unplanned changes in the demand for electricity. It is extremely important to assure a prompt reaction of such power plants to any possible changes in the grid. In this case, our priority is not the efficiency but the possibility to start up the plant within a few minutes. Usually, these are open-cycled gas turbines, turbine equipment being in an idle mode and electricity storages.
- In my point of view, as far as renewable power plants are concerned, wind farms and solar power stations should be classified into a separate group due to the fact that their energy generating capacities are strongly dependent on weather conditions and only an approximate forecast can be given in their regard. The advantage of these technologies is that they generate electricity on the basis of a natural – free of charge – source and do not lead to carbon dioxide emissions into the environment.

1.2. Energy distribution

Electricity produced by the electric power generating facilities is transported to the consumers via electric power distribution network. Electricity supply systems are comprised of the power grid and electric sub-stations.

1.2.1. Electric power grids

Based on the voltage and functions, electric power grids are divided into four levels:

- The backbone of the electric power grid is the so-called basic network. Its main function is to transport electric power from the power plants to the key electric sub-stations. Its voltage may be 220, 400 and 750 kV. Another task performed by this power grid is to provide connection between the unified European and national power grids.
- The main power distribution network is composed of sub-stations belonging to the basic network and receiving points of the main power distribution network. Large industrial consumers are connected to the main power distribution network. Its voltage is 132 kV.
- Medium voltage-based power distribution network is understood as the section located between the main power distribution network and consumer transformer sub-stations. This section is characterised by a huge amount of consumer branch offs. The voltage in this section may be 10, 20 and 35 kV.
- Low voltage electric power distribution network supplies electric power to the consumers. Typically, these consumers are non-energy-intensive businesses, households and public. Its voltage is 0.4 kV.

1.2.2. Electric sub-stations

An electrical substation is a set of transformers, switchgear, their protection actuating equipment, and devices belonging to the network nodes. These sub-stations and their respective voltages are divided into the following three levels:

- Sub-stations at the power plants: their task is to assure the transfer of electricity generated by the power plants to the basic electric power network by means of necessary voltage transformations.
- Sub-stations within the power grid: these are sub-stations installed in the regional nodes in order to establish the connection between the basic electric power network and electric power distribution network in accordance with voltage levels.
- Consumer sub-stations: are used for connecting the consumer electricity distribution network with the power distribution network. One of their typical features is that in case of certain environments, these sub-stations perform their function with the help of column transformers.

Depending on the current functionality, switchgear or transformer sub-stations are installed.

3. Applicability of drones in the operation of infrastructure

Electricity infrastructure provides users with energy using various and diversified technologies. Continuous electricity supply from the generating facility to the final user can be ensured through multiple power transformations; in addition, the generating facilities and consumers should be properly balanced to maintain the 50 Hz frequency. The common feature in the operation of certain types of power plants and grids is that they do not require the permanent presence of the operational personnel, have a large territorial coverage and are difficult to be approached. The above statement is true for solar power stations and wind farms, distribution sub-stations of the grids and high and medium voltage transmission lines. Drone technologies can be used to address challenges posed by common environmental specifics in the performance of operation-related tasks. The primary goal when designing unmanned aerial vehicles was aimed at addressing such application areas and purposes that turned out to be too dangerous for the pilots and would have endangered their life and health during the mission.

The application of drones has opened up opportunities for performing such tasks, which were extremely time-consuming and could not have been completed successfully by any of the pilots. Areas of applications in case of unmanned aerial vehicles include reconnaissance, surveillance and many other purposes [1, pp. 309–312].

3.1. Operation of electricity generating facilities with the use of drones

During the operation of solar power stations, certain diagnostic tests should be carried out at specified time intervals, in order to identify the local hotspots. When performing tests with the use of traditional test methods, the technician has to walk down the entire area of the solar power station with a thermal-imaging camera. The application of traditional methods would make this task a time-consuming process and in the case of large-scale solar power stations, due to the size of the area, it would not be feasible and could not provide the complete overview of the situation. In contrast, a diagnostic test performed with the use of a thermal-imaging camera and a drone equipped with the appropriate software provides a comprehensive overview of the temperature distribution throughout the entire power plant. Another positive contribution of the drone application is the reduction of time required for the test execution, the results can be evaluated immediately and the process can be fully automated. Owing to the development of information, management and production technologies, we are able to produce the computers with really tiny sizes and at the same time, the programming of small-sized aerial robots is no longer an obstacle. Current flight parameters transmitted from the deck of the UAV to the ground control point inform the operator and system administrator of the actual situation; the operator is monitoring the performed task and can intervene any time, if necessary [2, p. 279].

One of the most important tasks in the operation of wind turbines is the timely performance of external visual inspection, which can be used to reveal damage on the blades and, by doing so, to prevent the occurrence of more serious damages. Prior to the beginning of the wide use of drone technology, these tasks could be performed only at a high cost and with the loss of production time. The above task making a part of maintenance activities was carried out by industrial climbers having special knowledge and skills, and its performance was hindered by a number of environmental factors. Wind turbines are usually installed in groups, also known as wind farms. There are two types of wind farms in use. Onshore turbines are installed on the land, while offshore turbines are installed on the sea. Wind turbines installed on the sea are characterised by higher performance: their maximum power reaches 10 MW. The maximum power of wind turbines installed on the land is 3 MW, the diameter of blades can reach 113 m and their height can be up to 145 [5]. In case of dimensions exceeding those indicated above, on-land transportation cannot be solved, so the sea can provide sufficient space for the greater spread of the offshore technology characterised by higher efficiency. The development of image analysis software allowing the use of drones for multiple purposes, RTK technology[1] for positioning the drone with a cm accuracy, development of imaging cameras and thermal cameras also make a great contribution to the elaboration of efficient predictive maintenance programs for wind turbines.

3.2. Operation of power distribution grids with the use of drones

Continuous and safe conduct of operation is one of the key features in the operation of electric power distribution grids. Nowadays, the use of advantages offered by the drone technology is absolutely necessary during the performance of tasks required for the inspection and maintenance of high-voltage overhead lines. It is a special area where several risk factors exist at one and the same moment. One should be very attentive in this extremely dangerous environment caused by high voltage, should not forget about high altitude and should be very careful while working in hard-to-reach places all over long distances. A drone having RTK capabilities, equipped with a high-resolution and 20–30x optical zoom and a thermal-imaging camera on its deck, provides fast and safe access to critical areas during the survey conducted on high-voltage overhead lines. Haraszti and Őszi in their paper described the application of thermal imaging for the detection of contact corrosion through a detailed analysi f contact corrosion through a detailed analysis [6]. The application of drones can be a good option for the walk-down of power transmission lines. Individuals involved in the inspection approach the transmission line and then perform the inspection without de-energising using a drone with appropriate software; the efficiency of the test method can be significantly increased if the flight is performed autonomously by the drone itself based on the input parameters.

There is a high potential in the use of drones for eliminating the grid failures. The duration of eliminating power failure in the grid as a result of a possible fault can be significantly reduced. The use of drone makes a significant contribution to the minimisation of time required for failure detection, as the drone can be directed to altitudes of up to hundred meters in a matter of seconds, while the worker would spend at least an hour doing this job. If the protection function was actuated by a momentary failure, the drone can be used for energisation during the test.

4. Conclusion

At the beginning of this paper, I briefly presented the elements constituting the infrastructure of the energy system and then outlined the process of generating electricity and transporting it to the users. As one can see, the generated electricity is the resulting product received via

1 Real-time kinematic positioning.

the performance of diversified tasks, in the course of which there is a possibility of numerous failures occurring in subsystems.

As shown in this paper, the drone technology developed in the 21st century offers more and more possibilities for using drones in the surveillance, monitoring, maintenance and repair of energy systems. The extreme importance of drones is confirmed by the fact that the control of system components can be entrusted to the "autonomy" of unmanned aerial vehicles when we reach the appropriate level of autonomous operation with the support of artificial intelligence (AI). In this mode of operation, our aerial vehicle performs its flight task independently, under the supervision of a remote pilot, based on the pre-programmed route, while providing real-time data on the system component to be inspected using sensors mounted on the drone deck [4]. By means of this technology, maintenance costs can be significantly reduced, opening up additional opportunities to make maintenance activities more cost-effective, reasonable and secure with the parallel development of artificial intelligence and drone technologies.

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A drónok szerepe a villamosenergia-ágazatban

Ahogyan a villamosenergia-rendszerek szétválasztása és fejlesztése, úgy a repülés is a múlt században kezdte virágzását. Igaz, a két technológia kezdetben nem sok hatást gyakorolt egymásra, ám a 21. században eljutott arra a szintre a két rendszer, hogy a működésben, karbantartásban, a mindennapokban egyre nagyobb felületen, újra „keresztezik" egymás útját.

A szerző a publikációban bemutatja azt, hogyan épül fel egy korszerű villamosenergia-infrastruktúra, valamint azt, hogy milyen folyamat útján jut el az erőművekben előállított villamos energia a felhasználókhoz. Ezt követően a cikkben az olvasó megismerheti azokat az eljárásokat, módszereket, ahol a villamos rendszer egyes elemeihez hatékonyan kapcsolódhat az egyre több funkcióval és feladatrendszerrel felruházott dróntechnológia.

Kulcsszavak: *drón, villamos energia, erőmű, energiaelosztás, villamos hálózat, biztonság*

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