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POSSIBILITIES AND DANGERS FOR THE FIRE PROTECTION IN THE FIELD OF ALTERNATIVE ENERGY SOURCES

Abstract

Today, in addition to conventional energy sources (electricity from the network, natural gas, etc.), the use of various alternative energy sources is becoming more widespread internationally. In the field of alternative energy sources, the article focuses on the study of solar photovoltaic systems. In the field of related accumulators that may support the operation of photovoltaic, solar systems, the article reviews primarily lithium-ion accumulators. The fire protection issues of these alternative, renewable energy sources and storage facilities will be explored, using the available international literature.

Keywords: photovoltaic, solar panel, fire, fire protection, lithium-ion battery

A TŰZVÉDELEM LEHETŐSÉGEI ÉS VESZÉLYEI AZ ALTERNATÍV ENERGIAFORRÁSOK TERÜLETÉN

Absztrakt

Manapság a hagyományos energiaforrások mellett (vezetékes hálózaton elérhető villamos energia, földgáz, stb.) egyre elterjedtebbek a különböző alternatív energiaforrások alkalmazása nemzetközi szinten. Az alternatív energiaforrások terén a jelen cikkben elsősroban a napelemes, fotovoltaikus rendszerek vizsgálatára kerül fókusz. Az ehhez kapcsolódó a fotovoltaikus, napelemes rendszerek működését esetlegesen támogató és kisegítő akkumulátorok terén elsősorban a lítium-ionos akkumultárokat tekinti át a cikk. Ezen alternatív, megújuló energiaforrások és tárolók tűzvédelmi irányú kérdései kerülnek vizgálatra az elérhető nemzetközi irodalom segítségével.

Kulcsszavak: fotovoltaikus, napelem, tűz, tűzvédelem, lítium-ion akkumulátor

1. INTRODUCTION

This paper discusses the fire protection issues of different types of energy sources that are different from the general and traditional ones, and have been considered as alternative energy sources compared to them. During the investigation of the fire protection, the author examines the role and possibilities, challenges of preventive and rescue fire protection, with the aim that Hungarian and international research results and published publications in the field can be used in the professional field and in education. The basic starting point of the paper was that there are now considerable results, presented in a joint summary article, that can help fire officers, researchers and students in this relatively new field with a few decades of experience but no significant experience in eradication and prevention. In this paper, in the field of energy sources, I consider as conventional energy sources produced by various power plants (nuclear, heat, etc.), electricity coming from general energy networks or energy provided by hydrocarbons supplied through utilities (e.g. natural gas). I also consider it traditional to use various general fuels used to drive and operate vehicles, such as petrol or diesel. I analyze factors related to energy sources other than these, also called alternatives. One such alternative energy source in this area is the field of renewable solutions, here clearly the use of solar energy, also known as photovoltaic solar cells, can be one of the factors. There are several ways to get alternative energy, such as using water or wind energy. Among the traditionally available, almost constantly available energy sources, in case of electricity, we do not need to talk about its storage, without examining some special and rare areas (e.g., uninterruptible power supplies). When natural gas is used, in the case of installation away from the grid, its storage and its fire protection issues arise, but this is not the subject of this article. [1]

The use of alternative energy sources takes place as an island in several places, also in case of demands far from the electricity grid, but also in the case of mobile propulsion involving vehicles. Here, lithium-ion batteries can appear in the field of fire protection in addition to several benefits from the user side - based on the professional experience of recent years - with significant risks for the fields of prevention and firefighting. I describe the possibilities of

current fire protection issues of alternative energy sources, the results of which should be taken into account either when reviewing current professional and educational issues or when determining the directions of research in the near future.

2. METHODS

Regarding the fire protection of alternative energy sources, Hungarian and international scientific publications in recent years have been reviewed. The writings, the elements of which are currently becoming more and more widespread in Hungary and pose challenges for the fire authority officers and brigades, were especially targeted, such as the fire protection of solar cells, photovoltaic solutions and related - lithium-ion batteries for fire protection opportunities and circumstances. The content of the selected materials, scientific articles and publications, studies, the main lessons were analyzed and used for this paper. Especially targeted were the writings, the elements of which are currently becoming more widespread in Hungary and pose challenges for the fire officers, such as solar panels, photovoltaic fire protection and related - lithium-ion batteries fire protection, firefighting. opportunities and circumstances. From the content of each selected material, scientific articles and publications, studies, the parts containing the main lessons were analyzed more thoroughly and used for this article.

3. RESULTS

Dividing the results into two parts, the first part presents the issue of fire protection of **photovoltaic solar cells**. The second part describes the fire protection characteristics and new suppress possibilities of **lithium-ion batteries**.

3.1. Fire protection of photovoltaic solar panels

During the general use of solar cells in everyday use, more precisely photovoltaic solar cells, the following main factors affecting preventive fire protection and firefighting interventions

appear. In principle, properly installed solar cells (hereinafter referred to as the term) must not cause health damage or direct danger to the environment. We can also find roof-mounted, facade or ground design. The main source of danger is the topic in connection with improper design or various injuries and firefighting damage. In such a situation, the general firefighting activities must be applied and modified in a way that is appropriate for the environment. Naturally, the harmful physiological effects of electric current appear to be among the sources of danger, but also slip and fall, in addition to the issues of fire hazard.

Figure 1, 2 - Multiple fire risk and a flat roof with full of solar panels

Source:(e-on.hu, nvsolar.hu)

In the solution proposals, the tactics of firefighting interventions include providing a suitable place for firefighters to operate in the environment of the solar cell and preventing the spread of fire. Good practices include the provision of maintenance and firefighting work environments that require direct human activity during installation, the definition of issues in primary firefighting tactical regulations for primary interveners, or the development of solar systems themselves to take these into account. The fact that roof structures equipped with solar panels (or only the solar panels themselves) may be more easily damaged or torn off due to the higher weight load may also require the assistance of such manufacturers and developers. The glass surface of solar panels can cause slipping and, in the process, fall, which limits the area of free, safe movement of people, including firefighters [2] [3] [4]. In cases exposed to sunlight, solar cells naturally generate electricity even after the building is disconnected from the mains, even if not by high voltage or general mains voltage. Firefighter protective clothing may provide a lesser degree of protection in this field, but this should not be considered 100% safe [5] [6].

According to a previous study in Germany, solar hazards can also be lost due to the appearance of toxic gases, lower exposure to electricity, loss of concentration due to its “tingling” effect

and consequent collapse, but also fire propagation and flow factors that change compared to general rooftop fires.

“Fire Operations for Photovoltaic Emergency” has been defined in the United States. Based on this, we can find several recommendations that are also useful at the international level, quoting: Protect from potential hazardous chemicals coming from photovoltaic, solar modules on fire with the use of self-contained breathing apparatus (SCBA).

During operation in interior circumstance, water has to be directed on or near a solar system in a 30-degree fog pattern to prevent any electric current from traveling upstream toward firefighters. Firefighters must be at least about 10 meters away from the energized source.

During operation for search, the location of the solar-system-related components must be immediately relayed to the Incident Commander and all personnel working at the scene, and disconnect switches must be turned to “OFF.”

Overhaul, Fire Investigation, whenever possible, an overhaul of the fire ground should be delayed until there is competent confirmation that the solar system has been “de-energized.”

The presence of battery systems is a problem related to some of the alternative energy sources, in particular solar systems (in addition) or to the propulsion of vehicles, which issues by the batteries also appears in the second part of the paper. During the night, even in the event of a disconnection to the electrical network, voltage may be present in the building affected by the fire brigade. In addition, depending on the type of batteries, hazardous substances may be present. In the United States, design requirements for batteries are established to the battery systems used in the photovoltaic system by Chapter 52 of the NFPA 1, Fire Code, and Section 608 of the International Fire Code.

The Fireground Tactics can be: “Components are always hot!” It means for the firefighters to always consider photovoltaic systems, their components as electrically energized.

As a continuation of this, the usual procedure, but the prohibition of direct access and contact, may appear in the principles of fire intervention. After the fire intervention, it is important to leave the scene in a safe condition due to these issues too. There are need to develop the International and National Fire Codes in the prevention side. The possibilities to raise the safety level can be:

Provide ability for electrical system isolation for emergency responders and enough space for the personal presence. Standardized approaches to provide consistent identification of solar power systems and their components.

The systems are exposed to weather conditions that enhance the aging process, and the infrastructure needs to be inplace for the on-going maintenance and also helpful contact information for emergencies [7] [8] [9] [10] [11] [12].

3.2. Fire protection of lithium-ion batteries

Some of my sentences are directly from that work due their meanings. The solutions by lithium-ion batteries helps the transportation and energy storage also. It is smaller and lighter compared to conventional batteries (e.g. niccel batteries, Ni-Cd, Ni-MH). The problem with these kind of batteries, if the internal temperature of this kind of battery increases beyond its operating range, by external or internal means, so the components may become unstable and tend to generate heat. The temperature of the batteries can elevate further. The fire can be extinguished, but the effects of thermal runaway are difficult to manage, solution could be the cooling onward.

3.3. The phenomenon of the thermal runaway and the fire

Nowadays we are using lithium-ion battery in hybrid electric vehicles and electric vehicles, aeroplanes also. By a study, the conditions to thermal runaway and fire can be separated into four categories:

- Electrical abuse (e.g. over-charging or discharging)
- Thermal abuse (over-temperature above 200 °C).
- Mechanical abuse (penetration, pinch, and bend) caused by external accident (e.g. car crash or repairing, installation), can result in electrical shorting between the electrodes.
- Internal short circuit. By the failure of the separator, allowing contact between the cathode and anode via the electrolyte (e.g. due to any of the above abuse or manufacturing fault)

If these abuse conditions results increase in the internal temperature of the cell, can initiate exothermic reactions, occurs fire. The various abuse conditions resulting in separator malfunction and possibly thermal runaway, after fire ignition, what is hard to put out pemanently.

3.4. Techniques by the preventive Fire Protection

In the preventive side, the fire protection codes can measure for the cells, the batteries, its modules, the packing, the whole system and also the enclosures. The fire protection signs can take place outside of the battery or the system and compartment to give attention for the maintanance or the fire intervention.

The early fire detection and suppression also can help with the tools of Fire Prevention passively and actively [13]. This kind of fires can be detected by conventional heat detectors, smoke detectors or combined smoke-heat detectors.

3.5. To supress the fire, we can use more ways

By using **water**, it is the most cost-effective method to fight against fires. Water is an excellent cooling material and may be able to mitigate or halt the propagation of thermal runaway. By the way, water can react with and form toxic and harmful hydrogen fluoride.

Good solutions by four types of water suppressants:

- Water jet: a stream of water directly to burning materials. It provides cooling and inhibiting re-ignition.
- Water spray or sprinkler: a spray of fine water droplets. The spray can penetrate the fire plume and cool surfaces and the air.
- Water with added surfactants: We can add more types of surfactants to the water to improve the effectiveness of water extinguishment. By the surfactants, we can reach to decrease the water’s surface tension so that it coats better the burning materials and cools better also.

- Water mist: Water mist comprises different droplet sizes, smaller than from a sprinkler. Finer droplets have a large surface area resulting bigger absorption of heat energy from the air, water. For large batteries and its modules, it can be efficient due its low volumetric requirement and good cooling capability. We can raise the effiency by adding surfactant to the water source.

Suppress the fire can also be successful by using large amounts of water to the batteries. Also helps submerging the batteries in water.

By using **foam** fire extinguishants also can be used to extinguish fires of lithium-ion batteries. The foam cools and seals the surface so putting a barrier between flammable vapour and the hot surface and starving the fire of air. The efficieny also can raise if adding surfactant.

By using **powder** extinguishants, we can chemically interrupt the fire reactions. This way not provide cooling and re-ignition may occur after put out the fire. Powders can create breathing, safety problems inside [14].

4. DISCUSSION

Fire protection officers, workers need to see some alternative energy sources and fire protection features also on the preventive and intervening side. To help these fields, it is recommended to make more open experiments and publishing studies in this area, in particular with regard to the fire equipments and suppressants for use in different conditions.

Particularly important is the examination of energy sources that are larger for industrial, retail or daily home use, which is statistically higher in the likelihood of various fire-departmental tasks related to them. The following areas may be particularly interesting from these aspects: effective fire protection and firefighting interventions and safety issues in the area of the installed solar panels and in the field of energy storage, even on vehicles.

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