Таким образом, ЦАЛАР позволяет идентифицировать АР и определить сечение, по которому необходимо выполнять деление системы, за меньшее время, чем непосредственно наступает АР (таблица 1). А деление по сечению, соответствующему сформулированным критериям, позволяет уменьшить объем управляющих воздействий противоаварийной автоматики, в частности АЧР, в отделившихся частях энергосистемы.

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EARLY FOREST FIRE DETECTION SYSTEM NEAR POWER TRANSMISSION LINES USING WIRELESS SENSOR NETWORK

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Forest fire activity has been only increasing over the past decade, on the territory of Russia in particular. The scale of wildfires in Siberia in 2021 turned out to be larger than all other fires in the world combined. Although the Ministry of Natural Resources' data indicates that more than 77 thousand km^2 of forest burned in 2021, according to Greenpeace data, the damage done is twice as much as to data stated by Ministry of Natural Resources, that assessed only damage to forests near nature reserves and settlements.

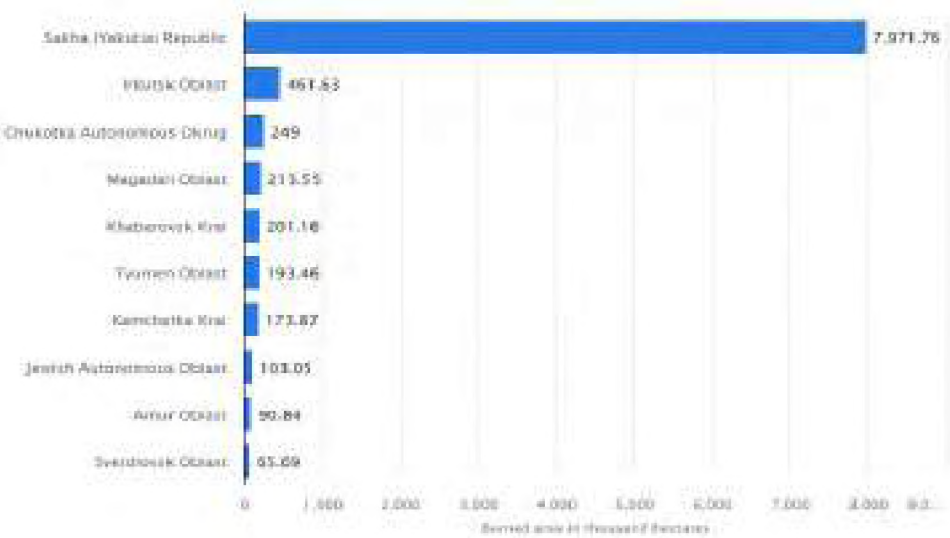

Fig. 1. Area burned in Russia in 2021, by federal subject (in 1,000 hectares). Research conducted by Statista [1]

Wildfires on the territory of the Republic of Sakha (Yakutia) have a seasonal pattern and their frequency is influenced by many factors. Considering that the wildfires can be caused by different heat sources, there are natural and human-caused wildfires. The major natural causes of the fire are the ones brought by global climate change: record-breaking high temperatures, reduced precipitation leads to lightning strikes creating fire during drought. And, according to Greenpeace's data [2], approximately 90 % of the all wildfires that occurred on the republic territories were caused by human action.

Moreover, the low level of forest service funding (6 rubles per hectare, in contrast to 180–200 rubles per hectare in the central Russia) resulted in poor monitoring of high-risk wildfire areas and lack of fire-fighting resources. It led the Government to increase funding of forest protection in Yakutia and, according to the head of the republic, Aisen Nikolaev, it has been increased by 5.6 times compared to the previous year.

Wildfires detriment our lives. In addition to the negative impact they have on environment and human health, they can deal catastrophic damages and lead to instability in the power system. Wildfires pose great threat to the utility infrastructure with the ability to cause power outages therefore putting reliable electricity service at risk. Additionally, the damage done by wildfires cause large financial losses and it also contributes to climate change.

When the fires are spreading the integrity of grid infrastructure is at risk of being damaged. Nearby burnt debris and trees may fall directly on utility infrastructures, such as substations and most frequently power lines causing serious physical damage to them full recovery of which will take long periods of time. Also, wooden poles burn easily during wildfires. The longer poles are exposed to heat of the fire, the more likely they are to be damaged or destroyed.

As for the wildfire damage done to the power infrastructure of Yakutia, according to information of Deputy Chief engineer of PJSC "Yakutskenergo" Sergey Prakapenka, in total 396 poles on 25 lines of all voltage classes were damaged over the fire-hazardous period in 2021 [3]. It is almost one tenth of the total number of poles of the Yakutia power infrastructure. It should also be mentioned that fires near power facilities lead to frequent power shut-offs which are necessary measure in preventing and putting out fires.

There are many methods that are currently implemented for forest fires detection, such as camera-based systems set on watchtowers, the use of satellite images with machine learning application, all having different sets of positive and negative aspects and fire detection performance. Additionally, in recent times the wireless sensor network (WSN) method has been attracting a lot of attention of researches mainly for its application versatility and potential positive features such as early and accurate fire detection.

The purpose of this report is to cover operation principles of a wildfire detection system based on WSN and consider implementation of such detection system near power transmission lines in order to monitor environmental parameters around them, therefore increasing the power transmission safety. The potential shortcomings and strengths of such design are also going to be stated.

Wireless sensor network refers to a group of multiple and dispersed sensors over the particular area for monitoring, measuring environmental parameters in real-time. The essential elements of the wireless sensor network are the wireless sensor nodes, cluster heads (CHs) and base station (BS).

A basic model of a sensor node includes a sensor module, processing module, communication module and a power supply module (figure 3). The sensor module senses the required environment's parameters. The processing module controls the operation of a sensor, managing the node's collected data or the data transmitted by other nodes. The wireless communication module is responsible for receiving/transmitting data and overall communication with other nodes. The power supply module supplies power to the modules of a node and is crucial in network's performance.

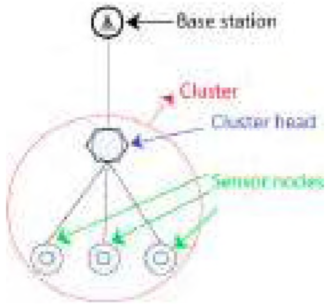

Fig. 2. WSN Topology

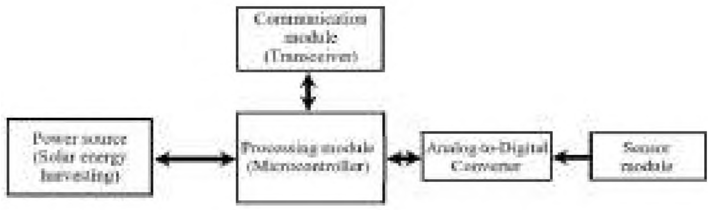

Fig. 3. Block diagram of a Sensor node

The sensor readings for each parameter are checked with a preset threshold ratio and a real-time ratio, once the ratios exceed the preset, the gathered data is then sent to the BS for analytical processing. In order to collect data from sensor nodes and ease process of communication with the base station, the sensor nodes are arranged into clusters. Each cluster has a cluster head which gathers sensor nodes' data and transmits them to the BS.

Base station is a crucial in WSN-based detection systems because of processing limitations of the nodes. Important data is transferred to the base station which acts as the gateway. If after analysis the model indicates a fire in a specific area, a message is sent to the responsible unit user.

A lot of research has been carried out and developments have been made in the field of WSN, in monitoring and detecting wildfires particularly. There are many works based on different sensors that focus on certain environmental parameters such as barometric pressure, temperature, relative humidity, gases such as CO, CO_2, methane, H_2, to detect forest fire conditions.

To detect wildfires near power transmission lines let us consider implementing sensors that were used in the work carried out in Germany by Institute of Forest Ecosystems. In the given work the hydrogen detection sensors were used that can detect hydrogen concentration increase at a distance up to 115 meters within 30 minutes which is considered quite effective for an early wildfire warning system [4].

It is also important take into the account the features of the power lines' landscape because of how it affects wind dynamics. To start off, let us consider how wind dynamics change in the landscape of powerline corridors. In order to prevent fire or any other type of hazards and maintain system reliability powerline corridors are created that lead to clearance of vegetation underneath and around powerlines. According to EPM [5], the shortest horizontal distance between the 220 kV power transmission lines and the crowns of nearby trees is 5 meters. This leads to changes of original shape of the landscape and creation of powerline corridors. According to the study "How fragmentation and corridors affect wind dynamics and seed dispersal in open habitats" [6], wind, entering such corridors, accelerates inside a patch which leads to high-speed winds at the end of corridors. Moreover, as seen in the figure 3, corridors rotate the wind direction so it is in line with the patch's long axis, in the same direction as the corridor.

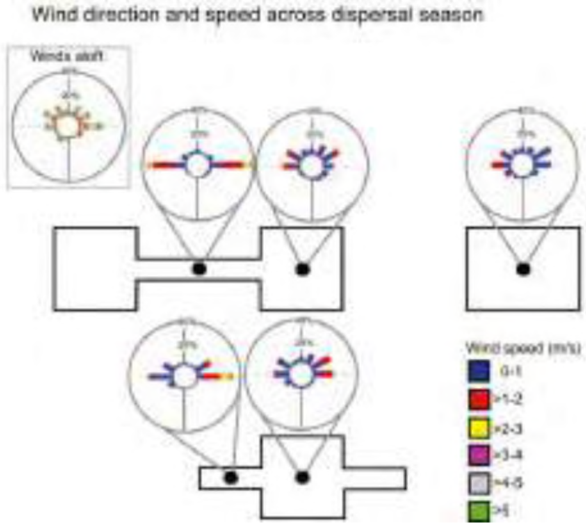

Fig. 4. Wind direction and speed across dispersal season

With this data, one can assume that during wildfires the landscape features of powerline corridors from the viewpoint of early and effective hydrogen detection are in favor of sensor-based wildfire detection system operation. Because gases released by a wildfire are mostly transported in line with a corridor powerline corridor at a high-speed which, hypothetically, has to lead to earlier fire detection.

However, from the technical point of view, there are obstacles for sensor operation near powerlines. One of the major issues is radio-frequency interference (RFI) generated by high-voltage transmission lines. The electromagnetic field due to corona discharge capable of interfering communication channels or devices over a wide frequency range. The frequency range of interference, approximately covers the range from 14 kHz to 1 GHz [7]. For instance, if we consider using system proposed in the work “Solar Powered Wireless Forest Fire Detection” that has a RF communication module [8], its operation close to high-voltage powerlines might be compromised. However, in the research “Investigating the Impact of High Voltage Power Lines on GPS Signal” it has been stated that electromagnetic interference is a significant problem when the following conditions are present: the power transmission line voltage is above 230 kV, the operation frequency of a device is less than 30 MHz and the distance between the power line and the device is minimal [9]. Since the chosen module is capable of operating at radio frequency up to several GHz, it should help decrease the lines’ interference impact. Nonetheless, it is desirable to keep an optimal distance between transmission lines and transmitter/receiver modules to keep the level of electromagnetic interference low.

To summarize the article, after the coverage of operation principles of a WSN system near power transmission the advantages and disadvantages of such design were noted. The main advantage being the powerline corridors’ landscape features that would increase speed of fire detection. Speaking of disadvantages, the main technical problem that was highlighted in this article is the radio-frequency interference (RFI) generated by high-voltage transmission lines which threatens the operation of WSN system but should not be a large problem since some devices can operate in higher frequencies. Moreover, the sensor notes can be set in a safe distance from lines.

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ИСПОЛЬЗОВАНИЕ ВОДОРОДНЫХ ТОПЛИВНЫХ ЭЛЕМЕНТОВ В СИСТЕМАХ ЭЛЕКТРОСНАБЖЕНИЯ

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С каждым годом экологическая повестка становится всё более серьёзной и распространённой. Многие промышленные компании и в частности электроэнергетические начинают задумываться о том, чтобы путём постепенного снижения выбросов углерода в атмосферу прийти к полному отсутствию выбросов парниковых газов. Одним из следствий «зеленой» повестки является развитие возобновляемых источников энергии (ВИЭ). В наше время среди ВИЭ наиболее распространены ветер (ветряные электростанции), вода (гидроэлектростанции) и солнце (солнечные электростанции). У всех них есть ряд серьёзный недостатков, но кроме этих источников существует огромная перспектива использования водорода.

В этой работе будет рассмотрено использование водородных топливных элементов в системах энергоснабжения, будут рассмотрены их перспективы, проведён экономический анализ и современные примеры использования топливных элементов, работающих на водороде.

Уже на протяжении нескольких десятилетий возобновляемые источники энергии занимают свою долю на рынке генерации тепловой и электрической энергии. С каждым годом доля ВИЭ в генерации электроэнергии становится всё больше и в 2021 году уже достигла 30%, большую часть из которых (более 15%) занимает генерация на гидроэлектростанциях. Доля водорода же на сегодняшний день безумно мала и составляет менее 0,5% от общего объёма генерации. Хотя в России развитие ветроэнергетики ограничено непостоянством скорости ветра, дороговизной установки и эксплуатации ветропарков. Солнечные электростанции также сталкиваются с проблемами сложного климата в большей части России: неэффективность в ночное время и сравнительно небольшое количество солнечных дней.

Также всё более актуальным для обсуждения становится вопрос о большем распространении электростанций малой мощности, и для этого есть свои причины. Электростанции малой мощности намного дешевле в строительстве и эксплуатации, при их возведении не требуется инвестировать средства в дополнительную инфраструктуру, а именно в линии электропе-