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Supply railway traffic control devices in case of failure of the power system

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ABSTRACT

The development of technology led to a situation where the developed economies are completely dependent on electricity. Access to energy sources modern power stations, the right structure and condition of the transmission lines as well as providing continuity of supply are the basis for national energy security. Failures in the energy system always result in financial losses incurred by both suppliers and consumers of electricity. The costs depend mainly on the scope of the accident, the degree of damage to the power system, the duration and the number of customers without power. The modern energy is facing a very long list of problems. Overcoming these problems is the basis of energy security of the country. The globalization of the world economy, next to its threats is also a cornerstone of the joint actions to ensure the continuity of supply of energy to customers. A very of importance then becomes ensure the functioning of transportation during system failures.

KEYWORDS: blackout, railway traffic control devices, power quality, disorders of the supply voltage

1. Introduction

It is obvious that a power outage causes the immobilization of consumers using electricity as a power source. Each user experienced such a situation. It was for him more or less problematic. In most cases, the duration of the power outage was short enough that it caused only minor problems mainly related to work (resets of computers, being not connected to the corporate network, etc.) or the functioning of the household (no lighting, no Internet access, being not able to use the house appliances).

Customers with receivers sensitive to power outage or voltage dips (hospitals, data processing centres, banks, etc.) widely uses reserve power supply (UPS, generators, energy storage systems).

Increasingly, there are situations when the recipients deprived of power are counted in thousands or even millions. In addition, power outages are long enough to cause a threat to human life and the very large financial losses.

One of the areas of the economy very strongly related to electricity is transportation. You can extract few branches of transport directly dependent on the power supply. These include metro, trams, electric cars or trains using electric traction. Air transport or cars are using fuel as a primary energy. However, indirectly, without access to electricity for a longer period of time, the operation of air and automobile transport becomes difficult or impossible.

In this article authors demonstrate the effect of systemic failure on the operation of transport, particularly rail, analyze failures that occur in different countries, as well as problems with the lack of power in Polish power system.

2. System failures in the world

We talk about the failure of the system when it concerns a large part of the national power system. Such failures are referred to as blackout. In recent years, the lack of power affects a growing number of customers causing huge financial losses [1].

Fig. 1 shows summarizes the time, the place and the number of population, Which suffered the greatest failures of the system in the world.

System failures affect almost all sectors of the economy and social life. The costs of the lack of power and poor quality of electricity are counted in billions of dollars. According to the report [2] in the United States alone the losses as a result of a failure in 2003 was estimated at approx. $10 billion.

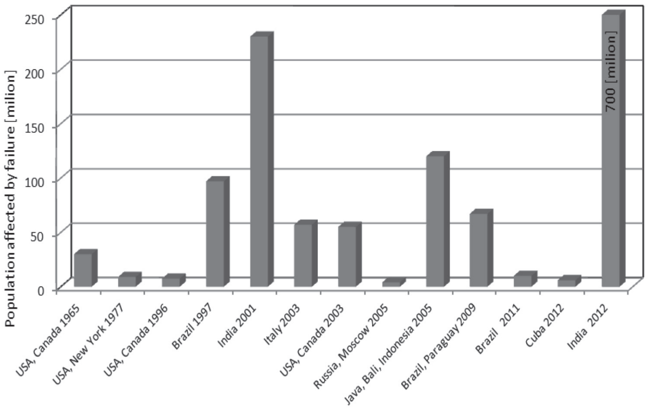

Fig. 1. The biggest system's failures in the world [own study]

The biggest failure of the system in Europe took place in September 28, 2003. The entire power system in Italy (except Sicily) has been disconnected from the European power system [3]. Failure lasting more than 20 hours affected more than 57 million inhabitants of Italy. It caused massive traffic paralysis in public transport. More than 30,000 people were evacuated in Italy from stopped trains. The passengers of the metro in Rome were waiting several hours for help [4].

Year 2003 was not the happiest for energy services in the world. In the first half of August 2003 a huge failure in the power networks in Canada and the USA has happened. No power supply lasted over 2 days and affected 55 million people. After eleven days, on the 25th of August, last generation units (power units) in Canada were re-launched [5].

Similarly, as in Italy, both in the US and Canada, a power failure has caused huge problems in all communication means of transport. As one of the first to feel the effects of a power failure were passengers of transport using electricity as a driving source. The evacuation of thousands of passengers from the subway and trains took a lot of time, and required the smooth operation of rescue services.

Fig. 2. Evacuating an elevated section of the NYC Transit subway [6]

People trapped in hundreds of elevators, enclosed in a small spaces had to wait for the release for several hours. Emergency services had a problems with quickly getting to the places which was the cause of such a long wait for help. Inoperative traffic lights heightened chaos in automobile communication.

Fig. 3. Swarms of stranded people attempted to leave Manhattan [7]

Hundreds of flights canceled and passengers stranded at airports are also consequences of the lack of power supply. It should be emphasized that air transport seems to be best prepared for such problems. This may result from a very large impact of weather conditions on its safe operation. Over the decades, the airlines have developed procedures to ensure the safety and comfort of passengers in emergency situations, both in the air and at the airports.

Fig. 4. Passengers crowd at a railway station as they sit on tracks while waiting for the electricity to be restored in Kolkata July 31, 2012 [8]

The failure, which affected the largest number of people (over 670 million) took place in India on 30-31 July 2012. Also in this case there was a powerful communication paralysis.

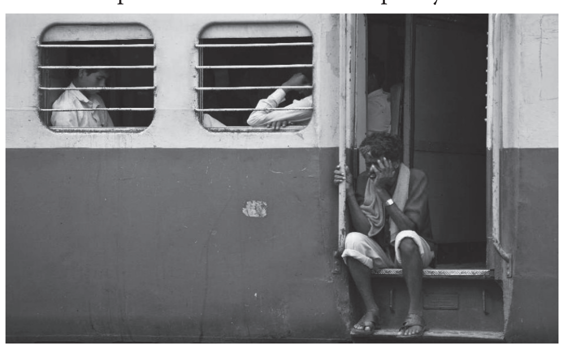

Fig. 5. Passengers wait on a train at railway station during the power outage in New Delhi [9]

3. Failures in the Polish power system

Failures in the Polish power system most often occur in distribution networks. They affect from several to tens of thousands of consumers, primarily municipal. The main causes are weather anomalies, like very strong winds, cable icing, lightning. Aging pipes and damage to equipment in the stations are additional factors increasing the risk of power outages.

Fig. 6. Damaged poles of a high voltage power supply Szczecin [10]

One of the greatest failures in the Polish power system took place on 7-8 April 2008. As a result of icing cables two main lines of high voltage 220 kV powering Szczecin conurbation were damaged - Foto 5. Also three lines of 110kV and a number of the medium and low voltage lines were damaged.

There was a pause in the work of the power plant "Szczecin" and "Pomorzany". 628,000 residents of West Pomeranian Province, including 330,000 in the Szczecin itself have been deprived of electricity.

Wires icing lead to the damage to the catenary of the railway line Szczecin-Swinoujscie. In the absence of power to operate the line Szczecin - Stargard Szczeciński diesel locomotives were used – Fig 7.

Fig. 7. Diesel locomotives pulling electric trains, Szczecin, 2008 [10]

Within Szczecin trams did not work. On the whole area covered by the disaster petrol stations did not sell, due to lack of power supply.

4. Powering the equipment for monitoring and controlling the rail traffic

Fundamental role in the security of the transport process are the railway traffic control devices and electronic systems controlled by them. In terms of quality and reliability of supply, these devices are classified as category I . Railway traffic control devices therefore decide on efficiency and provide to minimize the occurrence of threat to the security of railway traffic [11].

Security of electricity supply is provided from two independent lines and a reserve generator. Power requirements define technical guidance construction of railway traffic control devices. For block posts power from one line only is allowed as well as from manually operated generating sets [12]. Switching power supply from the network core to the reserve dispenses with the automatic switching reserve. Switching from one line to the other should not take more than 2 seconds. Starting the generator should be one minute from the power failure in the power supply lines [13].

For safety reasons, there are circuits that require uninterruptible power supply. These include: substitute signal circuits, shields warning lights circuits, red semaphore lights circuits. Energy from the batteries should ensure continuous operation of the receivers at least for a period of one hour [12]. Most computers supervising the operation of devices controlling rail traffic have UPS as a source of backup power.

In the event of a complete power failure in accordance with the instructions on running train traffic R-1, duty introduces a telephone command and report preparation of route [14]. Please note that the lack of dependence of electrical motion control reduces the security level to the first level.

5. Power generators as a source of backup power

Power generators are currently the primary sources of backup power for a receivers that require a continuous supply of electricity. Due to the very wide range of power they can be used by individual consumers, municipal and also by industrial applications. These devices are of particular importance in the event of a major failure in the power system. They become, for a few days, the only source of electricity. The operating time is only limited by fuel supply for the engine powering the generator. In the event of a system failure (blackout) the quantity of accumulated fuel becomes a key issue for the continuity of power. The analysis conducted by the authors indicates that the basic problem is the correct operation of petrol stations and assurance of fuel supplies to consumers [15].

Generator providing backup power supply is in a separate chamber of the control room. According to the instruction E-24 it shall be activated by the control service once a week for a period of one hour [16]. Employees of the control room should be adequately trained [17]. In addition to stationary units, mobile units are also used. The following are characteristics of the aggregates used for backup power devices SRK.

One of the units used to supply traffic control devices between Warsaw and Katowice in an intermediate station is the generating set ZSE25-3 400-A-06 with a power rating of 25kV. Starting unit occurs automatically. At the time of power failure, after approx. 10 seconds, the engine preheats itself for about 30 seconds. Then the signal is fed to the fuel solenoid and followed up by the generating. The unit has automatic regulation voltage with a 25% overload for a period of 1 hour. The tank is 70 litres of diesel.

Another unit used to power the railway traffic control devices at a junction between Warsaw - Katowice is generating set PAD63-3/400 with a rated power of 63kVA, with automatic start and stop. It is one of the larger devices used primarily on large nodal stations and marshalling yards. The current carrying capacity is 91 A. Fuel tank capacity is 120 litres, the combustion of 10-12 l/h.

Unit AP3-1000EA with a capacity of 10 kVA is one of the latest devices are used as a source of backup power-level junction on the line Warsaw - Krakow. It has an electronic voltage regulation (AVR) with a sinusoidal shape in the range of + 2.5%. (THD less than 4%). Fuel tank with a capacity of 35 litres can only work for a period of 12 hours.

If the break in the power supply line (main power) lasts from a few to several hours if power generators fully fulfil their role. They provide power for controlling devices, which are responsible for the safety of train traffic. The problems start to appear when the interruption lasts much longer. This may occur in the event of a major failure in the power system. It becomes necessary to bring fuel for generators, which at the present problems with transport and connectivity is not a simple matter. Power generators supplying units of special importance for train operations should have extra fuel tanks to ensure that they work for a few days.

6. Conclusion

Communication chaos accompanied every major failure of power systems in the world. It was particularly noticeable in large urban areas. No-power supply affected all types of communication. Immobilized metro and railway lines required the evacuation of thousands of passengers. Problems with traffic lights paralyzed car transport. People numbering in the hundreds of thousands tried to reach their homes To ensure the efficient transport as soon as possible seems to be essential. The key role is rail transport. Sufficient diesel locomotive power and traffic control devices can provide safe transportation for thousands of passengers. Due to the enormity of the problems arising from the lack of power, it is obvious that you can run only the key sections of railway lines. It is mainly determined by the amount of locomotives powered from an independent power supply than railway traction.

The authors draw attention to the need to provide backup power to devices SRK and communication and supervision of railway traffic for an extended period of time. Restoration of electricity in the power system can last several days. During this period, particularly large cities need commutation of basic products: water, food, medicines, fuel, power supply equipment in hospitals and disease control centres, etc. A failure in Szczecin agglomeration already showed the problems the inhabitants of large cities with a break in the supply of electricity have to confront.

When analysing failures in power systems occurring in the world, one should consider the possibility of such an accident in Poland. It seems appropriate, therefore, to develop procedures that allow for operation of railway traffic on selected sections in the event of a blackout.

In the absence of power to a large area of the country, the passenger service is a separate issue. Please note that tills, bank terminals and a considerable part of the equipment at the railway station do not work.

Only by the analysis of several major failures occurring in the last several years at the biggest station in Poland, Central Station, shows what problems are encountered by passengers in the event of a power failure.

Fig. 8. Evacuation of passengers at the Central Station, 2011 [18]

November 17, 2006 at 14.30 there was a power outage at the Central Station and Station Śródmieście. The cause of failure was a short circuit in the station GPZ Towarowa. Difficulties lasted several hours. June 22, 2011, there was another accident at railway stations Central and Śródmieście. At around 10.25 there was a total lack of power at these stations. Amost all devices did not work: railway traffic control, communications, ventilation, information, lighting, including emergency lighting. Fifteen fire brigades were carrying out the evacuation of passengers from both stations [18]. Movement of trains on the diametrical line between Warsaw East and Warsaw West has been completely stopped. More than 40 trains were immobilized and the passengers, for safety reasons, could not leave them for a few hours.

November 24, 2016 there was a failure of power supply systems for traffic control devices at the Central Station. Power outage which lasted more than three hours caused difficulties in conducting the movement of trains, which were directed to detours. Delays of trains reached more than three hours.

13 December 2016, failure of the computer supervising signalling equipment at the station in Poznan led to suspension of train traffic for more than 6 hours.

What's above, a several cases of power failure, shows what problems are met by passengers using rail transport. It should be emphasized that the absence of energy supply lasted up to 7 hours. In the case of high traffic chaos system failure embrace all types of communication, especially those dependent on electricity.

The services responsible for the safety and continuity of railway traffic should therefore be prepared for the occurrence of blackout. Development and implementation of procedures in the event of a power failure to the rail transport appears to be a priority. These procedures should provide a safe and fast transportation of people from large urban areas and the delivery of basic measures to ensure the functioning of key institutions in the city (hospitals, crisis centres, etc.).

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