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Case Study: The Use of Petrol Stations to Fuel Supply in the Event of a Power Outage

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Abstract

Long-term power outages represent a significant interference with the lives of citizens, institutions, and sector of critical infrastructure. One segment of critical infrastructure is healthcare. In this sector, it is essential to maintain functionality and provide ongoing healthcare to clients. At the time of power failure, alternative power sources are used in these facilities for which fuel supply is required. The aim of the paper is to analyze fuel filling stations for hospitals in the event of a power outage. The paper describes the use of petrol stations at the time of failure. Also, an analysis is carried out at a selected hospital regarding fuel supply and the determination of service stations for their supply. The PTV Vissim software will be used to analyze critical junction points for supply. At the end of the paper recommendations for the selected hospital will be proposed.

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Keywords: Power outage; petrol station; fuel supply; Czech Republic;simulation

1. Introduction

Nowadays, critical infrastructure is frequently compromised. The critical infrastructure protection were implemented into the Crisis Management field in the Czech Republic (Rehak, 2016). This term defines the crisis

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management law in the Czech Republic as production and non-production systems, whose malfunctioning would have serious implications for security, economy and the preservation of the necessary extent of other essential functions of the state in crises (Act no. 240/2000). There is no law to deal only with critical infrastructure and its disruption in the Czech Republic. There is only a government regulation defining criteria for identifying a critical infrastructure element. This government regulation defines cross-cutting and sectoral criteria. To the sectoral criteria includes - energy, water management, agriculture and food, health, transport, communication and information systems, the financial market and currency, emergency services, public administration (Act no. 432/2010). In Slovakia, the problem of complex risk management in the field of critical traffic infrastructure is quite new (Leitner, 2015).

If the element of critical infrastructure - energy is disrupted - it will affect the state's performance and its major infrastructure. Over a decade, the role of electrical power plays a major role in modern day life. Even a momentary power outage can create chaos, revenue loss, and loss of life. A temporary stoppage of power can be more disastrous when it comes to life-support systems in places like hospitals and nursering homes, or in co-ordination facilities such as in airports, train stations, and traffic control (Mutani, 2018). The power outage might be caused by cascading effect of the disasters. Natural disasters are disasters, which is an unpredicted phenomenon that mankind must address. Unfortunately, many important services like Medical services, transportation (people and goods) and electricity are disturbed during and after the disasters. In the last years, these risks had a growing impact on the energy sector through extreme weather events – disastrous, unusual or not seasonal events (Mutani, 2018). Transport is defined as a sector of the national economy that provides and carries out the relocation of persons and things. The narrower concept is the movement of transport means along transport routes or infrastructure (Drahotsky, 2003).

The day-to-day activities that rely on electricity are from the basics, like cooking the family meal, water heaters, cooling systems, communication systems and heating our homes, to key infrastructure services like petrol pumps, and modern conveniences like automatic door and many more (Kumar, 2016). Road transport infrastructure consists of highways, road, local roads, junctions, road bridges, road tunnels and crossings with other transport means (most often it is railway crossing) (Dvorak, 2012).

Transport, energy, information and telecommunications infrastructure sectors are the most important part of the critical infrastructure protection (Dvorak, 2017). Loss of power supply disturbs not only households, but also school facilities, health facilities, offices, and even petrol stations. One of the goals to improve the sustainability of cities is to invest in developing the resilience (capability to handle and respond to various disturbances) in order to substantially reduce disaster damage to critical infrastructure and disruption of basic services, such as the supply of energy (Sendai Framework for Disaster Risk Reduction, 2015).

There has been mentioned that a power outage has a significant impact on healthcare facilities such as hospitals. Hospitals should provide health care even during a power outage. For this purpose, the hospital is equipped with UPS and also with diesel engines. The UPS is used for the time necessary to recover the current through diesel aggregates. Diesel aggregates can replace power supplies; however, fuel supplies are essential for their operation. Some hospitals have fuel stocks for more than 48 hours. Some hospitals do not have such supplies, and it is necessary to ensure the supply of fuel to the aggregates. The supply of the different types of loads to the hospital might be different over the time horizons during a day according to the availability of logistic status of the fuel supply, where might be expected scarcity in fuel supply during blockades or conflicts (Hijjo, 2015). That means that mobility of fuel must be ensured. In transport policy, mobility means the ability and willingness to change the location of raw materials or goods based on the primary requirements of an individual customer. This customer may be a natural person or a business unit. Here it is necessary to respect the conditions created by the external environment (state, transport policy) and by the relationship between the customer and the service provider and in compliance with the agreed requirements (Drahotsky, 2003).

The aim of this article is to analyze petrol stations in the Zlín Region. This analysis will serve to determine the operation of service stations at the time of failure of the power supply. The aim is to find out the possibility of supplying hospitals with fuel from the petrol stations. Another paper goal is to simulate a critical junction by the hospital using the PTV VISSIM software. Transport modelling using computer is in the file of traffic engineering and building effective working of the multiple expansion to solve complex tasks and problems. VISSIM is most often used to evaluate proposals for transport infrastructure, traffic management proposal on the road and simulation benefits of telematics traffic management, public transport simulation and so on (Korfant, 2017).

2. Methodology

Four methods of scientific work were used in this article. The method of analysis is used because it uses the principles of logic to achieve the set goal and provide the framework to explore the principles of crisis preparedness of the hospitals and transport of fuel to the hospital. The induction method was used, where this method serves to examine the fact of creating a hypothesis from the points obtained. Generally, this method is based on generalizing conclusions based on the lessons learned about the individual elements of the group. From the scientific point of view, the outcome of induction is always a mere assumption or hypothesis. Next was used compasion method. This method is used in the comparison where the same or different sites of the examined objects or phenomena are evaluated, and corrections are made by the results obtained. Finally, the software PTV Vissim was used for the simulation.

The software which is used in this paper was PTV Vissim. PTV Vissim software is used to simulate transport services for the selected hospital. It is the software that solves microscopic simulations of individual and public mass transport. This program can affect both urban traffic, including cyclists, and motorway sections, including significant, cross-country intersections. The extensive analytical tools gathered in Vissim make it a tool for traffic planning and optimization of transport and transport systems, as well as some interfaces for different traffic management systems.

Vissim simulates some familiar but also unique geometric and operating conditions that occur in the transport network. The Vissim can define an unlimited number of vehicle types allows the user full range of multimodal operations. Types of vehicles include passenger cars, trucks, buses, cyclists, wheelchairs, pedestrians (Software PTV Vissim, 2018).

PTV Vissim software uses Wiedemann vehicle movement. The underlying assumption R. Wiedemann´s is such that the vehicle may be in one of four driving modes.

Uninfluenced ride - the driver is in no way affected by his movement. Thus, it moves in the determined direction and at the selected speed. It is not affected by moving vehicles or commands according to traffic regulations. In fact, the speed is dependent on the accelerator pedal and therefore is not constant. It is one of the reasons why the speed is entered in Vissim at intervals (e.g., 50 km / h is introduced at a range of 48-58 km / h) (Hofhansl, 2011).

The vehicle approach process - the driver, gradually approaches the forward vehicle and progressively moves the speed until the desired safety clearance is reached between the car and the first vehicle.

Follow-up - the car follows the previous vehicle without any change in speed (except the speed variation at the specified interval). It is driving at the same speed as a vehicle in front of it and still keeps its safe distance from it.

Braking - if the driver cannot keep the required safety distance (the car is in front of him), the vehicle gradually decreases its speed and stops.

3. Results

The first problem, which we need to solve is the number of petrol station works around the hospital in time of power outage. There was analyzed the petrol stations in the Zlín region. The Czech Republic is divided into 14 regions, and each region has a different number of hospitals. In the Zlín region, there are six main hospitals. These hospitals need to work in times of crisis too. There is an enormous difference in the number of fuel supply in each hospital. Some of them need to fuel to their aggregate. There was analyzed the petrol station in the area of the hospitals if they are working in the time of power outage. If they are working, they need to have aggregate for their petrol station.

The regional hospital in the Zlín was chosen for this analysis.

Table 1. Analysis of the petrol station

Petrol station	Working in times of power outage	Destination from the hospital (km)
PS1 – Příluky	No	1.8
PS1 – Jižní svahy	No	5.2
PS1 – Slušovice	No	12.4
PS1 – Otrokovice	No	15.2
PS1 – Napajedla	No	17.5
PS2 – Rybníky	No	3.6
PS2 – U Majáku	No	5.8
PS3 – Prštné	No	4.2
PS3 – Kunovice	No	30.4
PS3 – Přerov	No	41.5
PS3 – Bzenec	No	45.7
PS4 – Napajedla	No	13.5
PS4 - Slavičín	No	29.3
PS4 – Valašské Klobouky	No	36.1
PS4 – Buchlvice	No	36.5
PS4 – Osvětimany	No	45.3
Countryard station Otrkovice	No	13.1
State warehouse of the fuel	Yes	34.7

The table shows the analysis of the petrol station in the Zlín region. There was analyzed four types of the station based on the owner. Next, there was analyzed kilometers from the selected hospital to the petrol stations. However, based on the analyzes we can see, that none of the petrol stations has not the aggregate. That means, that none of the petrol stations will work in the time of power outage.

The use of an external supplier of fuel is only one of the solution to this situation. This contractor must undertake to provide fuel also at a time of power failure. In the Zlín region, ČEPRO has its warehouse. It is also able to provide fuel at the time of power failure. This warehouse is from the county hospital at 34.7 km. The critical point is that this stand-by storage facility also requires funds at rest.

Secondly, the aim of the paper was the simulation of the critical junction (Fig. 1). The hospital lies in a place connected to the main route of Vyškov - Zlín - Vsetín. This road is busy, and the transport of fuel will take some time. It was assumed that the possibility of using a closer petrol station near the hospital where the simulation would be performed. Therefore, the simulation will be performed at a selected junction near the hospital.

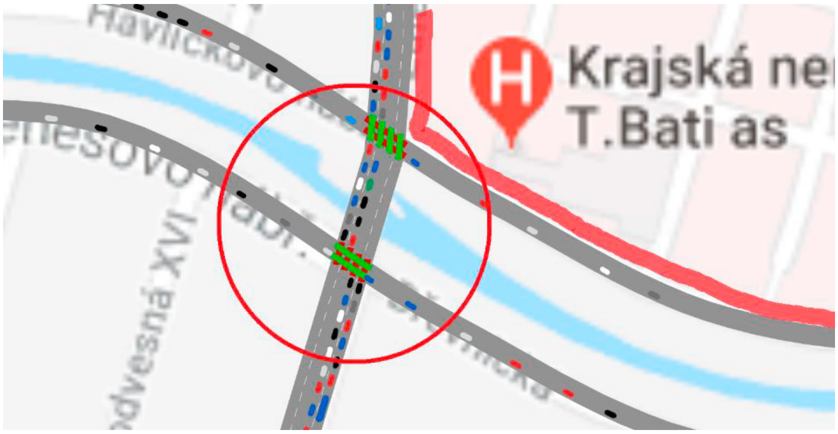

Fig. 1. Simulation of the selected junction.

From the simulation of the selected critical junction near the hospital, it is evident that this problem is a problem with higher traffic. Because of the high frequency of vehicles, there are columns in the branch line to the hospital and thus to further constipation. This can affect the arrival time of ambulance vehicles with hospital clients. In the case of fuel supplies to the hospital, a delay may occur for the car to supply the fuel.

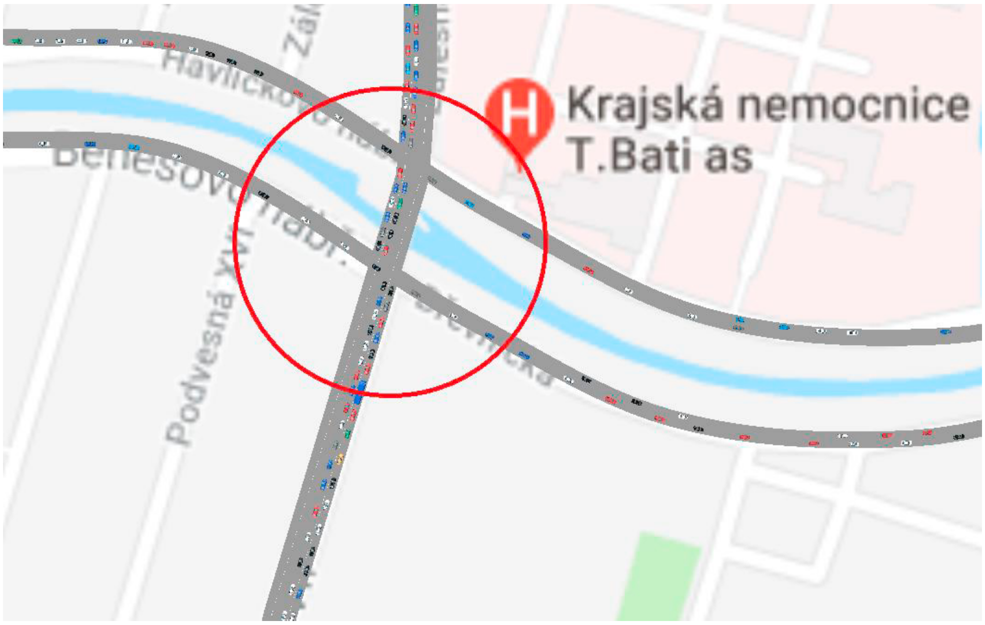

Fig. 2. 3D simulation of the selected junction.

The figure 2 also shows a 3D simulation at the critical junction at the hospital (Fig. 2). This figure presents columns and inappropriate traffic situation near the hospital.

4. Discussion

This paper has set two goals. Firstly, the primary aim of this article was the analysis of petrol stations in the Zlín Region. This analysis was used to determine the operation of petrol stations at the time of power failure. Secondly, the aim was to perform a simulation at selected critical crossroads at the hospital.

It was assumed that it would be possible to use a petrol station near a selected hospital. This hypothesis was refuted, and it was found that no commercial pumping station was able to operate at a time of power failure. Based on the analysis, it was found that hospitals would have to arrange an external fuel supplier. This supplier may be a state-owned enterprise, ČEPRO, or another external contractor, who will prove to be able to deliver fuel also at a time of power supply failure. Simulation of a selected critical junction near the county hospital was also carried out. This junction is busy and highly used. The simulation revealed that there were columns in the hospital lane, which also affected the main road to the hospital and the main route. It affects not only the arrival time of the Medical Rescue Service, but it also changes the transport time of the fuel from the external contractor.

Therefore, the hospital might choose a suitable supplier of fuel in the event of a failure of large-scale electricity supplies. The state enterprise ČEPRO was selected as the most ideal in the Zlín region. The disadvantage of this company is that it requires funds to keep it on standby. The amount of these financial costs amounts to CZK 10,000 per month (approximately 385 EUR). That means that the economic value of maintaining the alert for the year is CZK 120,000 (4620 EUR). It generates the hospital additional financial costs. Information from ČEPRO was notified that no enterprise in the Czech Republic has yet concluded this agreement. However, to address the lives and health of clients in the hospital, it is essential to address this issue. Alternatively, the state system should be changed. Here it would be appropriate if the ČEPRO fuel providers were obliged to keep the emergency room free of charge, not for a fee. The goal of each state is to protect its citizens and not to tackle it through the financial commitments of hospitals to the state fuel supplier.

5. Conclusion

The article dealt with a case study that dealt with the use of petrol stations to supply fuel in the event of a power failure. The aim was mainly to analyze petrol stations. This analysis has shown that none of the crowded public petrol stations near the hospital might provide fuel in the event of a power failure. Simulation of a selected critical junction near the hospital was also carried out. This simulation resulted in a complicated transport at the hospital's arrival point. It may lead to a prolongation of the supply of fuels to the aggregates. At the end of the thesis, a solution was proposed to ensure the supply of fuel in the event of a failure of large-scale electricity supplies.

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