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POWER SUPPLY BOTTLENECKS AT THE MANUFACTURING SECTOR

A VILLAMOS ELLÁTÁS SZŰK KERESZTMETSZETEI GYÁRTÓI KÖRNYEZETBEN

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Abstract

Electric supply is essential for most manufacturing processes. As the electric energy supply provides power for the safety devices and lighting also, modern human cannot imagine life without it. The power is essential for most supply chain processes. Power cut is a huge risk – might cause consequential damages – the system must be handled as critical infrastructure. The article describes some bottlenecks of the power lines within and outside the factory.

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Keywords: *Electrical supply chain Electrical maintenance, Electrical safety backups*

Absztrakt

A villamos energiaellátás nélkülözhetetlen a legtöbb gyártási folyamathoz. Mivel a villamos ellátás adja az energiát a legtöbb biztonsági berendezéshez és a világításhoz is, a modern ember elképzelni sem tudja az életét nélküle. Az energia nélkülözhetetlen a legtöbb ellátási folyamathoz. Mivel az áramszünet nagy kockázat – az áram hiánya következményi károkat okozhat – az ellátó infrastruktúrát kiemelt infrastruktúraként kell kezelni. A cikk bemutatja néhány szűk keresztmetszetét a villamos ellátási láncnak a gyáron belül és kívül egyaránt.

A mű a KÖFOP-2.1.2-VEKOP-15-2016-00001 azonosítószámú, „A jó kormányzást megalapozó közszolgálat-fejlesztés" elnevezésű kiemelt projekt keretében működtetett Concha Győző Doktori Program keretében, a Nemzeti Közszolgálati Egyetem felkérésére készült

Kulcsszavak: *Villamos energia ellátás, Villamos karbantartás, Vészüzemi energiaellátó rendszere*

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INTRODUCTION

Electric power is so common nowadays, that on the developed side of the Globe, human cannot imagine how to live without it. Most lighting, cooling, heating and vending services are relying on the power. Actually, at Hungary there is no factory without electric power supply, as most technologies require power in the industry.

The power mostly arrives by power lines. It is very rare in Europe, that any food manufacturer had standalone electric power source such like generator as normal supply. Depending on the factory size the site might have own power transformer and duplicated sources. Usually all energy comes from a Power Station [1] as local renewable energy sources are not well developed yet. Worst problem is with electricity, that only minor amount can be stored efficiently at site. The rest must be available instantly from the network [2]. All the sources must be synchronized and the power should be transferred on high voltage lines direct to the customer. The high voltage stands for system efficiency. As this network is a huge supply chain, it can be modelled by graphs and weak points can be pointed out to reduce the loss hours to keep it to an acceptable level.

As the distance between the power plant and the customer can be extreme long – even more than hundreds of miles – the voltage must be transformed up to reduce the transverse loss. The high voltage cables are held by pylons on the field. High voltage requires big distance between the wire lines and also between the wires and the Earth, so all this pylons are quiet high.[3]. If the voltage is higher, the pylons must be built higher also to keep safe distance between the Earth and the phases.

We can have the question how to manage this complex power supply network as an end user at site,

POWER FROM THE STATION TO THE CUSTOMER

To understand the local risks it is necessary to understand how the system is built outside the site. As the distance between the Power Station and the customer can be extreme long – over hundreds of miles – the voltage must be transformed up to reduce the transverse loss. High voltage requires big distance between the lines and the earth, so all this pylons are higher as the Voltage increases. [3]

Used transfer voltage levels at Hungary: [4]:

- 3kV, rare
- 6KV, rare mostly at industrial plants
- 10 kV, in towns and villages
- 25 kV, in towns and villages
- 75 kV, used for transfer
- 120 kV, used for transfer
- 220 kV, used for transfer
- 440 kV, used for transfer

750 kV is used for international transfer mainly. As seen on Fig 1. the load must meet the supply otherwise the system can become short on energy and becomes un-stabile. Huge network and load optimization is constantly in progress to keep the balance. As soon as the load is more, than the available supply the frequency drops. In case of a specified decrease of the frequency the system shuts down a main load, such like an industrial plant to keep the balance or tries to request power from the international line to cover the request. The estimated load is all the time forecasted by the supplier, so some power stations are running

mostly in the mornings and evenings meeting the highest consummation. Also seasonal consummation is forecasted so power stations are mostly maintained not in high-season such like winter time or hot summer time, when the consummation is higher, than the average in the spring or in the autumn.

Without power an average factory object experiences much more security gaps than in a normal day. I am stating, one of the best practices is, if a local factories maintenance tasks are meeting with the supplier's maintenance plan. In case of transformer maintenance the loss off production will be less in this case and the object safety increases.

Most customers have no control on the mains. Basically at Europe most of the time the power is available: only very short powercuts are common. It is very rare to have a power cut over 12 hours in towns. In negligible cases the power cut can be longer. The last few years the worst power cut was in the East-North location at Hungary [5]. Due to bad weather conditions there was no access for the repairs of the fallen cables for the Service Engineers. The recovery took about 72 hours after the first report, causing extreme bad customer feedback.

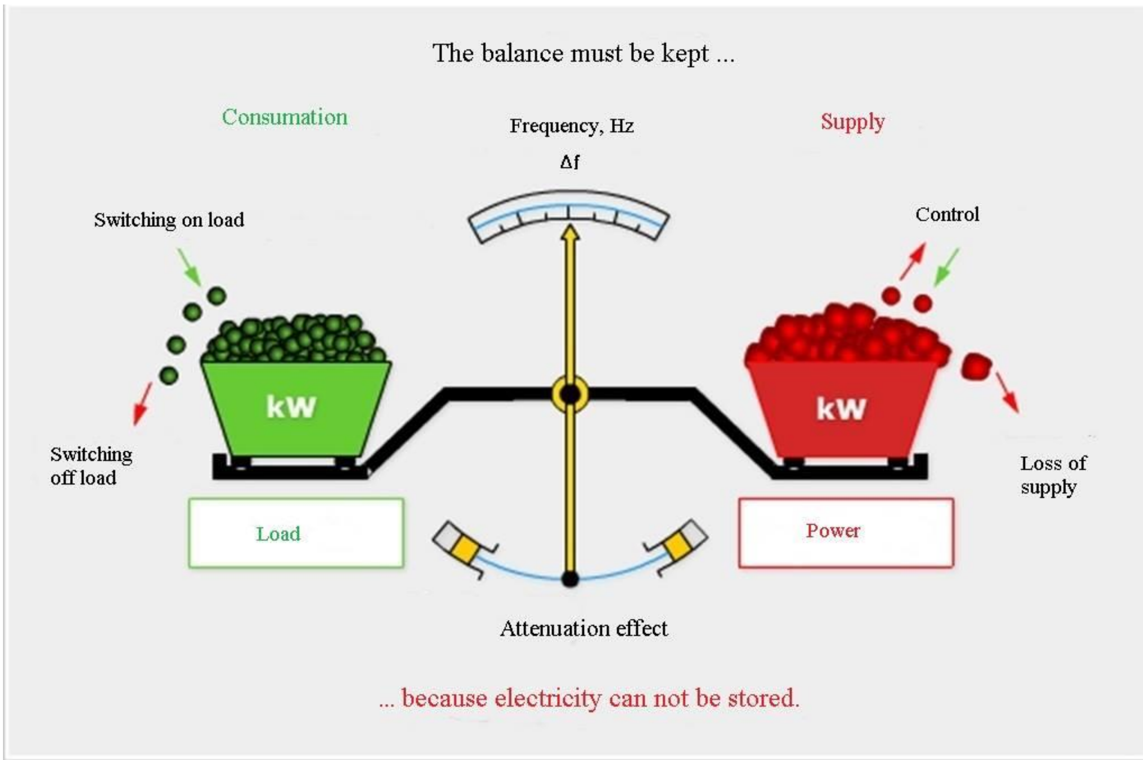

Fig. 1. demonstrating balance of the supply and load. Translated by the Author using [6]

There are several researches available [7], [8] [9] about weak point of the lines. At Hungary there are several points, where the power lines are too concentrated and they are not really monitored or guarded due to the network's size. Actually it had already been proven by others, that in case of terrorism, the pylons could be destroyed and cause power cut in a big location.

Fig. 2. International links around Hungary. Translated by the Author using [10]

To destroy a pylon is not a huge job for a technically trained soldier or illegal fighter. Most of the pylons are bolted only, even with home made thermit, even with standard maintenance tools the HV[1] power line could be destroyed overnight. Average customer cannot optimize manufacturing to cover this worst case scenario. In case of terrorism most of the factories would stop manufacturing and they would wait for recovery. Basically an average customer will not have full backup in case of mains loss due to the costs of the backup gears. As per my experience at Europe the power is mostly available and only the special loads are using local backups. Payback for the average size factory is not coming back when installing fully redundant sources, such like local generators. In other sectors it is handled with redundancy. In case of a datacentre, where the data loss is a huge money the power backup system is requital.

Power stations are managed following much tighter security rules comparing to the network. Most power stations have own armed guards (Fegyveres Biztonsági Őrség, FBŐ)[2] at site, such like at Paks. [11]. Basically to attack a power plant is too complex task for an average team, but terrorists have already tried at Belgium [12]. Access to the high voltage lines are much easier – anyone can walk close – so they can be pointed out as a bottleneck. As there is no fence camera installed, the beam could be destroyed overnight by maintenance tools available at the next door's shop. The author estimates that destroying one pylon would not affect the energy supply due the duplicated supplies. Actually about 10 points being destroyed in a close location at the same time could cause one day stop at an average town. Still not a huge affect in money and security, but it would be a big win in for a terrorist group.

In a longer term there is a solution for this type of risk. As soon as the digital RC[3] equipment will be cheaper it might be a solution to save the poles with identical alarm or camera or drone system, allowing to the reactive staff to arrive to the affected location in time.

[1] High Voltage
[2] „FBŐ" = Armed Man Guarding
[3] Radio Controlled

PARTS OF THE NETWORK WITHIN SITE

Local mains

Most industrial customers have own HV power transformer at their site. The trannies are mostly 10KV/400V rated at Hungary, but at bigger sites 25kV/400 Volt transformers are used too. Depending on size plant might have 2 supplies and switchgear. The switchgear uses the primary supply as normal supply. In case of fail it automatically loads up on the secondary supply by the switchgear. If both of them fails - after a several second of timeframe - the diesel generator starts up, if exist. Most factories are using the normal circuits for manufacturing. All water and steam plants, general cooling, lighting and most GMP[4] areas are fed form the mains usually

As the service level in Hungary is very good, also it is very well ruled [13. §1.-§130.] this solution is absolutely safe for most factories. The general supply is used for night lighting and several other services such like normal computers.

As the risk of the loss is not too high, the average customer relies on the service provider. In case of power cut the guards and the staff is trained to meet at the rail point, or they are asked simply to wait until the power comes back. It is obvious that in case of power cut the manufacturing stops.

Local uninterrupted power supplies

In case of power cut some part of the object might be pointed out as a bottleneck. In this case the mostly required equipment should be connected to an uninterrupted power supply (UPS) which are having mostly battery or diesel backup..

Some essential services, such like fire alarm system, telephone centres and datacentres have their own and identical UPS system to keep the service availability at a high level. The availability might be tracked by a KPI (Key Production Indicator) which is a useful data for the management to estimate if their supply is good or poor. The UPS might use chemical energy (batteries) for a shorter period and a diesel generators are used for longer periods of cut. Both of the parts are critical devices and should be maintained on a regular basis.

I am stating, that poor maintenance on this equipment or over optimized cost cut on this essential services increases the risk of the bottleneck within the object safety. Also at the FMCG[5] sector the poor maintenance of the units above might affect the product safety. That’s why all of this equipment should be tracked by the factory’s normal audit procedures.

As per my research and industrial experience I am stating that un-valid maintenance logs are affecting both of the product and objects safety, and the order of the savings are coming mostly from the local management, which are acting up for higher profit. At international environment that’s the reason why the owner uses international audits to validate that their assets are safely maintained. Actually one of the worst practice is, if a factory orders and pays for its own audit, leaving integrity fail in the factory processes.

Special power supplies

Safety devices such like fire alarm system, gas detectors, safety lighting have their own built in un-interrupted power supplies to support essential services during the power cut. Their

[4] Good Manufacturing Practice
[5] Fast Moving Consumer Goods

batteries - mostly lead-acid based - are charged within their built in charger. The battery should be replaced on regular bases as part of the maintenance.

Poor maintenance of the electric supplies feeding safety devices is a clear bottleneck in the object safety. Even a fire alarm panel would work on mains, with poor supply the system might end up in a not working condition and in the real emergency situation could cause consequential damages. Worst case scenario should be investigated on a regular bases as part of the Emergency Response Plan. (At Hungary it is called SKET). In case of power cut the proper response for an unwanted emergency situation will be slower, than on an average day. Most of time the Fire Recovery services are busy already at other sites and the service of the Fire brigade itself will show up as a bottleneck. As the recovery response might be slower than a usually, in case of emergency, such like an accident or fire cannot be solved in the same time as usual, when the power is available. If the sensing of the fire is slow - as there is no power for the alarm system –it can increase the risk of the fatal accidents.

To reduce the risk, one of the best practice is to keep all gears in a good working order and well maintained condition. Also it is important to keep human at site when possible. Actually a well maintained automatic alarm could warn the local people quickly, and the local staff can act instantly. Human attendance is an important part, as human can make decision instantly, can stop small fires with small extinguisher and also they can ask for help in case of bigger issues.

Drivers

Most motors at the factory nowadays are not designed with star-delta switches or normal contactors rather with converters [14]. Due to the energy efficiency the main stream is to follow the Sustaniable Development rules [15]. Also the start up current is limited by the energy contract [16] so most companies buy motor drivers for new installs.

Object safety relies on the power supply availability. More modern drivers are complex PCB based equipment. Basically they do not like power cut, the supply should be stable and constant.

Risk of power fail

Most factories stop instantly in case of power cut. This is a security gap within the object safety. At the FMCG sector the industrial cooling, central heating, lighting boiler houses etc. are effected instantly. Most cases even if the - plant has power generator - just the IT and the safety devices are connected to the generator. Obvious, that in case of power cut the actually manufactured food becomes waste as soon as the technology or the timeframe leaves the legally allowed parameters. All of the readymade consumable food should be recovered and transferred to different storages as soon as possible.

As most cases all lighting are also affected, staff should be ordered to meet at the Fire rail point, and all of them should be trained for this scenario.

BEST PRACTICE TO KEEP SYSTEM UP AND RUNNING

Most industrial sites(depending on size) have own Energy Manager for sorting the invoices and support the energy policy. If the site is not that huge to require a full time employee, the task is usually subbed out for a specialized contractor. At Hungary most cases the 10 kV transformers are maintained by the suppliers. The rest should be maintained and controlled by the local management. Switchgears and panels should be maintained in a regular basis meeting the Hungarian Fire regulation (OTSZ) [17]. Full maintenance – containing heat camera surveys- should be carried out at least once a year, but rather quarterly. If a site is not maintained, it will turn up soon as huge risk within the object safety as might ignite fire at the weakest point.

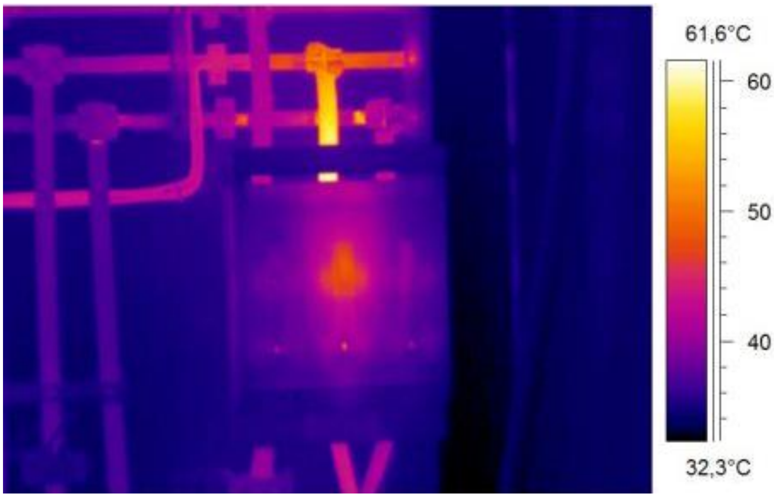

Fig3. T phase is overload and not torqued. System should be balanced and maintained. Source[18]

As seen on Fig 3. the thermo cameras are helping to identify the weakest points. It is not enough to torque just the loose connections, all bolts around the panel should be maintained on a regular basis to prevent loose nuts.

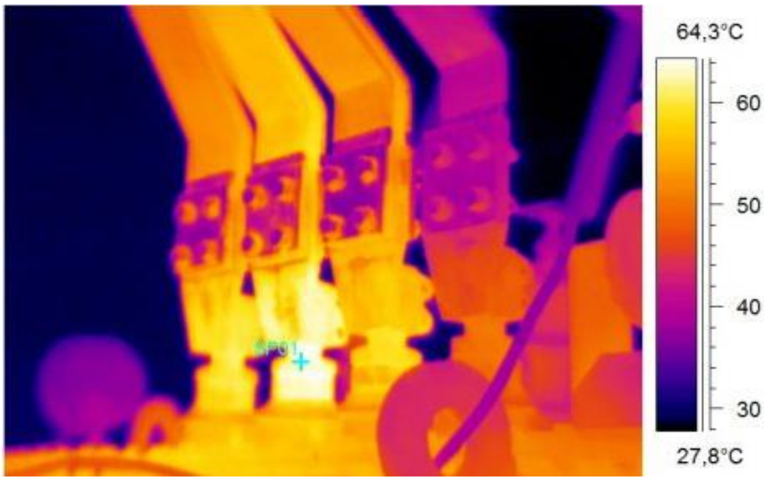

Fig4. Un-Torqued connection around the ceramic insulator. T phase connector is about 70 C. [18]

Metal to metal connections – seen on Fig 4 and Fig 5. - should be torqued down often. Electric connectors are mostly made from aluminium or copper. The end of the cables might be tin covered. The bolts are made usually from steel with tin cover on them. Some cases copper bolts are used. Between metal-metal surfaces there is a resistance, which is much higher when the joint is not tight. As the resistance increases, the joint starts to act as a heat source which provides extra force on the bolt forcing to lose it. Sometimes the joint cools back, and after a while the connection becomes faulty. Depending on the location the issue must be solved by the service provider or the local engineering team, but it must not be ignored just because the factory must run 24/7.

To prevent this type of fault on a regular basis the preventive survey should be managed, and the regularity of the faults should be tracked. All this tracking will act as a footprint in the maintenance. As per the internal audits, this documentation should be saved and logged. Basically if there is staff change within the engineering team, the data loss can stay as a bottleneck in the system making harder to investigate faults related to the object and fire security.

This reports are highly affected by human integrity risk.

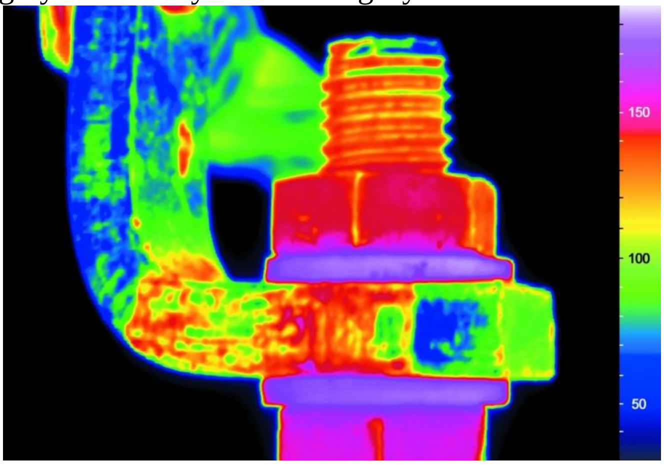

Fig. 5. Un-torqued nut. The temperature is well over 100 C. Source [18]

Should the company wish to run the production in 4 shifts following a continuous production plan, the maintenance plan should follow this request. Basically the plan must have some gaps in the timeframe, when the equipment are well maintained. As soon as the company ignores the maintenance request due to the high demand of manufacturing order (in FMCG prior to Christmas and Easter) there are several consequences should be treated with grate care:

Consequences:

- planned maintenance procedures will rather turn into reactive maintenance,
- planned costs will turn up as saving but reactive costs will increase and become stochastic,
- unexpected random stops within the supply chain,
- the risk related to the object security increases,
- risk of fire increases,
- maintenance plans at the factories are becoming useless, hand managed operation turns up.

CONCLUSION

At the food manufacturing sector the plants are mostly relying on the live power. In case of power cut the UPS and diesel generator systems can support the essential services, but any power cut is still a high risk for the object security. Within the site there are usually several units like switchgears, panels, fuse boxes which should be maintained on a regular basis meeting the local regulations. Also the management must be aware if the gears are not maintained on a regular basis the risk of fire increases. The regular maintenance is a legal requirement also. One of the best solution can be the thermometric inspection carried out on a regular basis around the equipment. As the unmaintained points can be picked up by surveys and the affected part can be re-maintained to reduce the risks.

Management has the legal responsibility for the maintenance. International audits might control management integrity fails as well.

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