Emergency Situations Management with the Support of Smart Metering

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Today's extreme weather conditions cause more and more emergency situations every year. These emergencies represent a big challenge for today's power supply companies.
The task to be solved in these critical situations is the processing of the huge volume of incoming data and their transmission by one-line messages (tolerant protection signals) to the operation controllers. In addition to this, high-tech equipment is to be provided in order to handle the large quantity of internal and external data and information.
According to the opinion of the Research Group of Applied Disciplines and Technologies in Energetics (AD&TE), the optimal solution to deal with the above challenges is the use of Smart Metering devices. The implementation of these devices will result in two directional communication which reduces troubleshooting time and simultaneously supplies the required quantity of information.

Keywords: management of emergency events; Smart Metering

1 Introduction

'Climate change represents a big challenge for human societies. Anthropogenic activities (air pollution – with a growing amount of greenhouse gases, environmental damages, land overuse and overpopulation) contribute to the climate change both directly and indirectly. Our own health defense system is weakened by these irresponsible activities. A multitude of emergency events and catastrophes illustrate the way the climate conditions become more and more extreme. The relation between global climate change and extreme weather events is obvious - any climate change causes changes in the weather conditions.' [1]

Extreme weather conditions have an important influence on the activities of network operators as well. Extremely high temperatures can damage the underground power cables, strong winds and ice formation can lead to the failure of the overhead electrical transmission lines disrupting the continuity of energy supply. [11] [12] [13] [14]

Todays difficult financial situation of utility companies causes the decline of the operation efficiency and reduces maintenance investments [15] [16]. The lack of investments results in a greater density of weak points in the networks, increasing the risks during their operation.

Figure 1
Overhead lines affected by an emergency event in the area of ELMŰ-ÉMÁSZ
(ELMŰ Hálózati Kft., 12. 2014.)

2 Electric Supply Companies Tasks during Emergency Events

The electric supply companies tasks during emergency events can be divided into the following: general preparation, direct preparation, emergency management and evaluation. These tasks are handled by the different departments of the Distribution System Operators (DSO) (Figure 2)

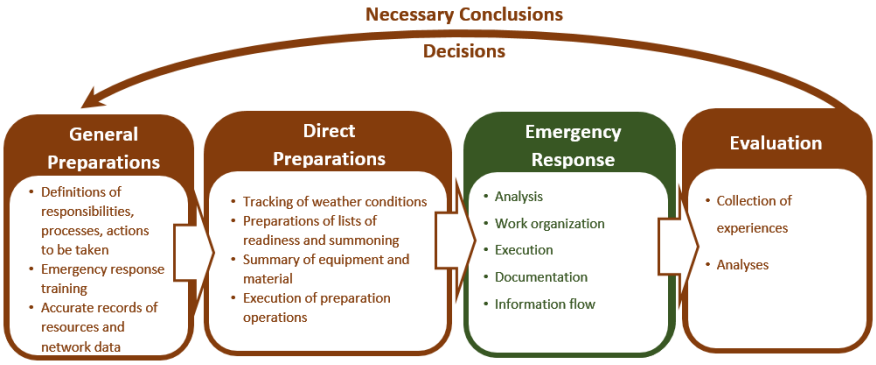

Figure 2
Task list for preparation to emergency events and restoration of services [3]

The general preparation for emergency events happens during normal operational conditions, well before the emergency event takes place. During this preparatory period, procedures and responsibilities are defined, tasks and duties identified.

Comprehensive resource- and equipment registers support the organisation of the work of specialists dealing with emergencies. The emergency response cycles are worked out in detail, the responsible people to make decisions are designated (Figure 3).

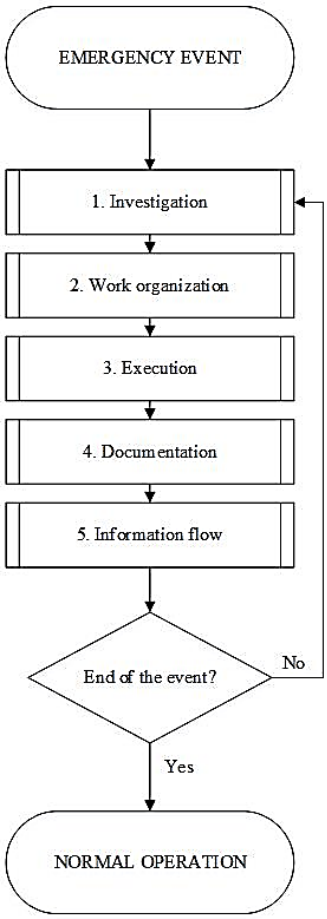

Figure 3
Flow chart for failure management in the power supply network during emergency events

Emergency events initiate complex processes. The first sign of an emergency event (inside the operation and control systems) is given by a sudden surge in the number of protection signals and consumer error reports. These together trigger the situation analysis and the delimiting of the affected geographical areas. Operation and work controllers take action, evaluate the available resources and, whenever the case, order the deployment of additional personnel and equipment.

The organization of troubleshooting activities is carried out taking into account the professional competences of the teams, the qualification level of the experts, the geographical position of the equipment and errors requiring attention. Due to efficiency reasons, the same specific teams handle the errors geographically close to each other or which suggest similar type of failures (for example: reports about flooding of a power station which requires pumps). During normal operational conditions, the distribution of the error or failure reports (failure addresses) is managed by the mWFM (automatic dispatcher) [8]. However, the mWFM is not capable of managing emergency events.

A new work organization strategy could be to reverse the above workflow by the distribution of a whole region or area to a working team - geographical area based work assignment instead of a failure report based one. In this case, the documentation of the management of error addresses, failure reports and protection signals will be handled post-event.

Following receiving the work instructions (nowadays in a digitalized form) the troubleshooting teams are dispatched on the spot and proceed to the delimitation of the exact position of the failure. Only after localizing and identifying the type of error – failure of an equipment or network element - can they proceed to carry out the troubleshooting works. On MV networks this working process is directed by the MV operation control, on LV networks by the LV operation control. The latest coordinates also the troubleshooting works.

Documenting the process is an important part of the troubleshooting. During normal operations this is relatively easy to execute, however during emergency events it can be a very demanding and complicated task. Reported back information is processed continuously which may initiate further processes through which the implementation and development of additional equipment and material, additional personnel or resources, external subcontractors or organizations (e.g. disaster management) may be required.

During emergency situations troubleshooting teams change continuously their geographical position. The materials, equipment supply and stock varies. Accordingly, the teams, equipment and stocks can be reorganized and optimized. Reorganisation of troubleshooting teams takes into account the peronnel competence, qualifications, exhaustion degree, etc. The incoming of failure reports, the development and “discovery” of new error locations lasts until the very end of the state of emergency. The emergency response cycle (Figure no. 3) can be as short as a couple of minutes during an intensive storm.

Continuous internal and external communication of the actual situation is an organic part of the process.

3 LV Operation Control Support during Emergency Events at Present

During an emergency the top priority task is to support the troubleshooting team(s) in charge to restore the normal operations mode. The technical staff (regional managers, controllers, directors, etc.) of the DSO helps in the localization of the failed network elements, in the unification of the interrelated error addresses, in the organization, troubleshooting and data sharing.

However, in many cases, due to the large amount of error reports, the LV operation control dispatchers fail to properly manage the emergency event.

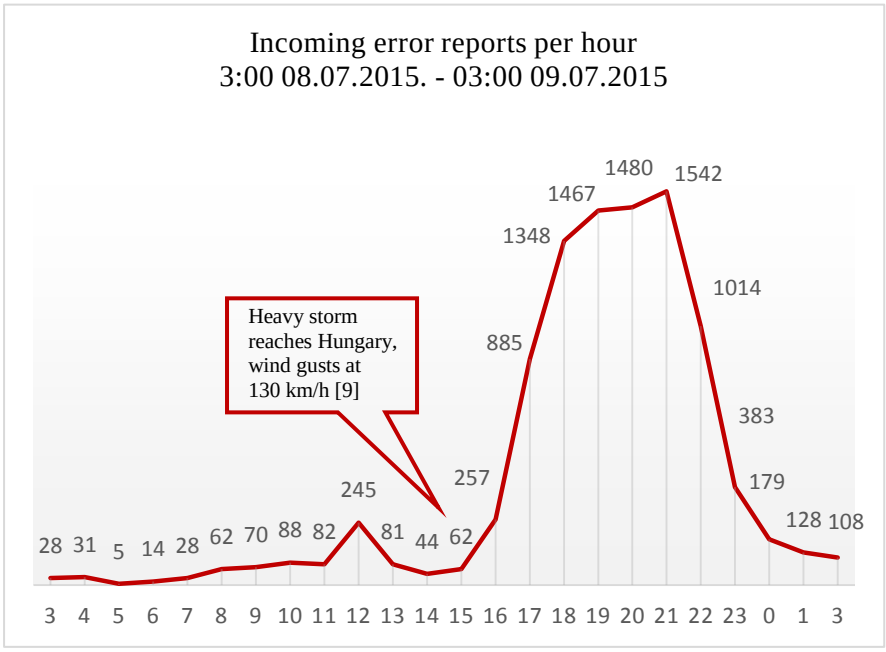

Figure 4
Incoming error reports (per hour) ELMŰ-ÉMÁSZ,08–09. 07. 2015.

This big volume of data hinders the optimal decision making process. Temporary, on short-term, the decision making process can be paralyzed. On longer terms, with regards to the entire time span of the event, the troubleshooting process will be slowed down.

Operation control systems currently filter and summarize error reports per LV circuits (provided that there is available network data in the system to the report address). In a given district of a transformer outage, relations to MV errors are handled by the previously mentioned human resources. This task can be replaced in the near future by proper digital support systems. The workflow made up by the

processing of the huge amount of incoming data (Big Data) and their transmission without redundancy to the troubleshooting teams in the form of one-line messages (tolerant signal) can be automated.

Another task is to provide the large amount of information requested by the different parties: authorities responsible for the protection against catastrophes, media (newspapers, TV, etc.) and internal departments (executives, fellow departments, etc.) This is a top priority duty as failure to perform it properly can cause a decreasing of the public satisfaction (due to itspower dependence': heating and cooling, traffic, communications, IT, cash registers, healthcare equipment, internet, etc.), negative media attitude and political uncertainty among others. [4] [21]

The management of these problems can be optimized by using Smart Metering. The implementation of this tool creates a two-way flow of communication which significantly improves the emergency event management and responds to the above-mentioned information demands.

4 Emergency Events Management with Smart Metering

The main goal of the Smart Metering (SM) is to improve the efficiency of the given energy systems (these can be: electricity, gas, water, central heating, etc.) and to increase the quality of their service. In order to control the demand, to implement intelligent metering and influence the energy consumption habits, the energy supplier needs to better understand the consumer. Using this knowledge he will be able to offer customized solutions. This will allow offering discounts to the consumers that will improve the utilization and optimisation of the capacities of his own systems as well. For example, the energy supplier may offer a price discount for consumptions outside of the peak time [5].

Further advantages of implementing Smart Metering are:

- the increase in energy efficiency by rending transparent and trackable the consumers' energy consumption,
- the possibility of monthly invoicing based on real consumption (instead of lump sum rates and 'monthly reporting') by connecting Smart Meters to the DSO's invoicing systems [5],
- replacement of HFKV and RF methods [19] [20],
- fast and reliable data service for consumers using the two-way communication via the SM display: information about the start of repair works, notice before the start of maintenance works, 'calm down messages' during emergency events, etc. (the precondition is that the Smart Meters will be equipped with battery and 'acknowledged' button),

- more transparent tracking of produced and consumed renewable energy,
- tracking down the ilegal consumption [6] [18].

In the event of a failure at 0.4 kV LV or at MV without substation protection signal (three-phase breakdown, meltdown of the LV/MV transformer primary fuse, heat protection meltdown, etc.) the operation control gets instant, full-scale report about the consumers without service, the failure locations within the network and their number. By this, the delimitation and the repair of errors can be more quickly assigned and executed. At present, the information about these types of failures is received only via consumer reports. [6]

A further problem to solve is the synchronization of the addresses, that is the assignment of consumer addresses to the network elements. At present, this type of data is not fully available on the LV network.

The error reports are organized on the lines of a monitor of the coordinating dispatcher:

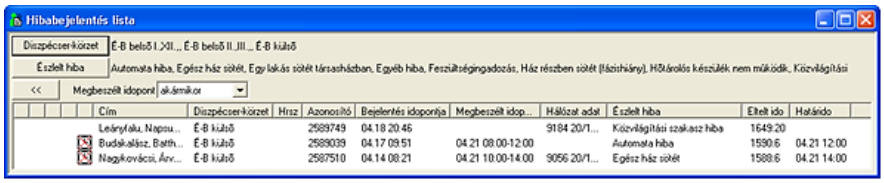

Figure 5

Error reports module of the LV operation control and work management system 'Mirtusz' at ELMŰ-ÉMÁSZ [22]

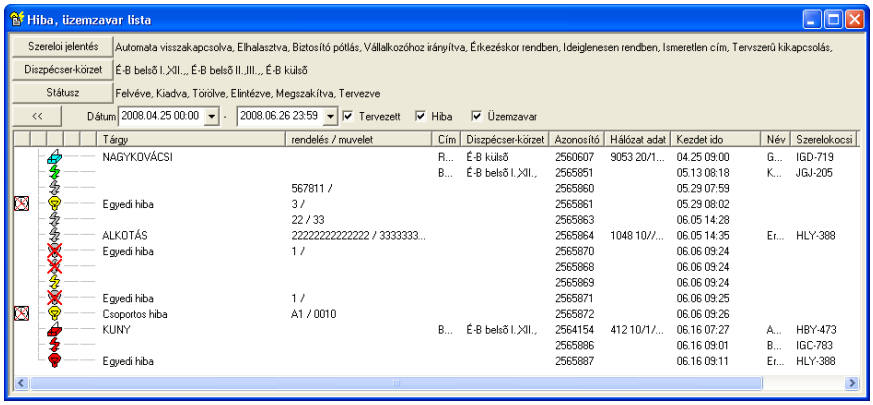

Figure 6

Error and malfunction list module of the LV operation control and work management system 'Mirtusz' at ELMŰ-ÉMÁSZ [22]

During normal operations the magnitude of 10-50-100 reports is easily understood and managed. However, this type of visual presentation is insufficient during an

emergency event. The solution to the problem is given by ***the introduction of tolerant signals*** based on SM, the ***identification of affected network elements*** and the ***modern visual presentation of data and information.***

There are currently available technologies for the visual presentation of LV and MV network data (outages, error reports, etc.). However, these are not used in real live situations. The input data for the E-software currently consists of error reports received via Tele Centers in the form of error addresses (Figure no. 7).

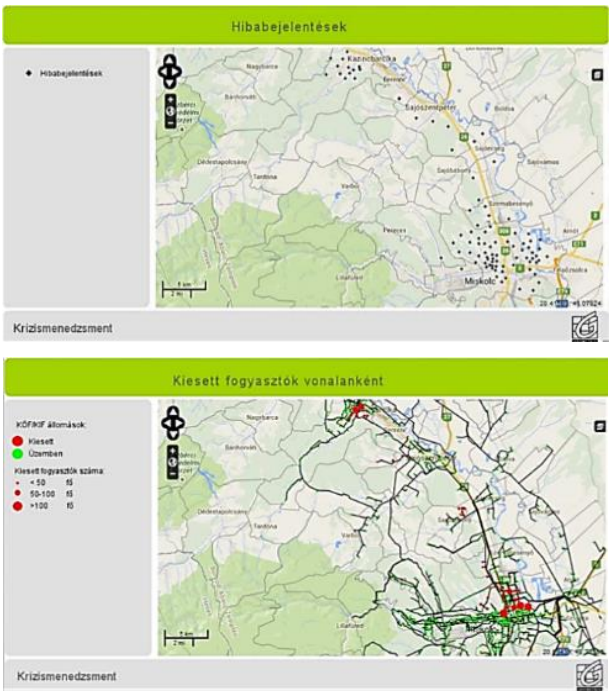

Figure 7
Displays for visual presentation of error addresses (left) and MV outages (right), developed by Geometria kft. [3]

The on-line and SM-supported displays applied in LV control centers provide significant help during normal operations. However, their use proves to be especially advantageous during emergency events.

In addition to presenting error addresses and failed LV network elements, the equipment is required to manage the on-line presentation of

- the position of the troubleshooting teams (with detailed features list displayed as pictograms),
- the network elements affected by HV/MV malfunctions (which, because of the network hierarchy, also affect the LV network elements),

- the network elements that are affected by the planned works (this gains function primarily during normal operations, since planned switchings are postponed in large quantities during emergency events).

A further advantage of the system is given by the high quality sharing of information with the external and internal data demanders: graphic, highly accurate and online data is available to the control, support personnel, executives and external organizations (e.g. media, authorities for protection against catastrophes, etc.).

5 Real Time External and Internal Communication with SM

Outage data can be used online. It can be made public in real-time providing instant and detailed information to the public and other organizations about the state of the troubleshooting process. In practice, the external-oriented information would be published based on the data of SM by the person responsible for the internal communication of the energy supply company:

- 'Informative-calming' messages to the consumers affected by outages (per region or per district) received on the display of the measuring meter.
- Situation reports sent to external organizations and authorities responsible with the protection against catastrophs.
- Information to the media (in the form of situation reports).
- Internal information for the executives, in the form of situation reports, for the preparation of further measures and for decision support.

The number of incoming calls of Tele Centers (TC) can be reduced significantly by the implementation of new communication systems.

By implementing the real time communication with SM:

- Accurate and detailed information about the emergency event can be provided to all the parties involved in the troubleshhoting process.
- Disaster control and external organizations can optimize the coordination of equipment (aggregators, pumps, special vehicles…) and staff more efficiently.
- Media receives accurate information.
- The more accurate information for the executives will help taking optimal, precise and well-grounded decisions.

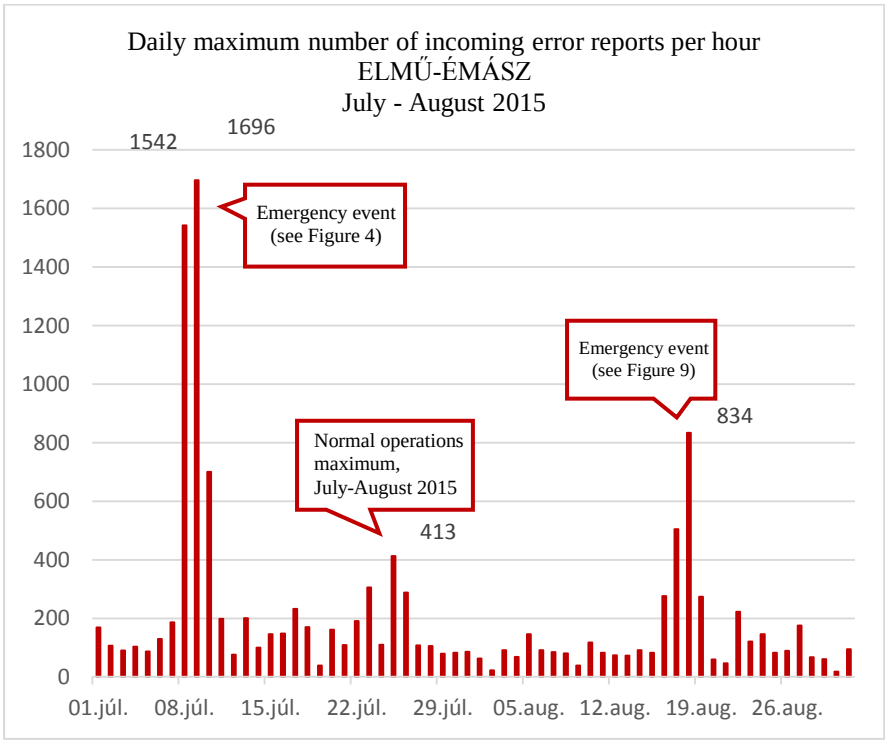

Figure 8
Daily maximum number of incoming calls (per hour) during normal operations and emergency events, ELMŰ-ÉMÁSZ, July-August 2015

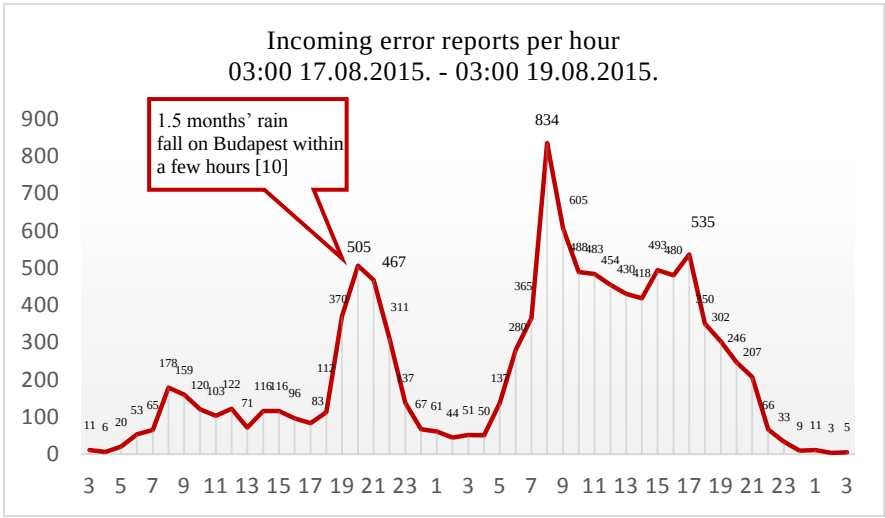

Figure 9
Incoming error reports (per hour), ELMŰ-ÉMÁSZ, 17-19. 08. 2015

Conclusions

Electric networks can suffer serious damages during extreme weather conditions. The rapid restoration and reparation is a complicated task. The emergency teams are able to fulfill their job with the help of current operational systems. However, in order to mitigate damages and to shorten service outages caused by the deficient operation of the power system new developments at system level are required. As an example, the establishment of optimized LV operation control centers and the development of technologies and tools which can provide quality support to the troubelshooting process. Further research of these support systems and the implementation of the findings into the real life practice will result in a higher quality of service.

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