DEVELOPMENT OF MAJOR POWER DISRUPTION MANAGEMENT

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ABSTRACT

Today's society is highly dependent on a reliable distribution of electricity. Since 2010 distribution system operators (DSOs) in Finland have faced several extreme weather-related major power disruptions each year. The most severe extreme weather events in the past few years has been storms Tapani and Hannu in December 2011 causing outages to 517 000 customers in Finland.

The mitigation of impacts of weather-related major power disruptions requires a variety of development actions of which one of the most important is changing the network structure to underground cables. Although this is considered to be the most effective measure against adverse weather-related outages it also takes the longest period of time to implement. Therefore improvements in the utilisation of network automation, ICT-systems and the development of processes can result in significantly advantageous results in a very short term.

This paper will focus on the process development initiatives concerning network control centre operations and a new model for fault repairing activities in the field to minimize the impacts of weather-related major power disruptions.

INTRODUCTION

After the storms Tapani and Hannu in December 2011 the Ministry of Employment and the Economy quickly drafted actions for improving the reliability of electricity distribution in Finland. These regulations came into force via the Electricity Market Act (EMA) in September 2013. The EMA sets targets for improving the reliability of delivery. After the transition period ending in 2028 power outages due to weather-related incidents have a maximum allowed duration of six hours in urban areas and 36 hours in rural areas. Furthermore there is a requirement for a mandatory network development plan and also a plan for preparedness and the management of major power disruptions. Since the 2003 amendment, the EMA has included the requirement for legal outage compensation for customers that have suffered an outage longer than 12 hours. Elenia has had its own voluntary compensation for outages longer than six hours since 2009. In the regulation model for DSOs in Finland the power outages affect the allowed reasonable financial results of the DSO via a regulatory outage cost.

Elenia Oy is the second largest DSO in Finland with 417 000 customers and 67 000 km of network. Today 31% of Elenia's network is constructed as underground cables and cablification of the network is proceeding to a target of 70% by the year 2028. This will in time greatly reduce the impacts of extreme weather events. Again in short and medium term development actions for managing major power disruptions have a very good cost benefit ratio and even after 2028, a relevant part of the network will still consist of overhead lines.

While investing heavily in underground cabling Elenia has also been one of the forerunners in smart grid development. All the electricity meters are smart meters (AMR) and are connected to the Distribution Management System (DMS) to provide a clear overview of the low voltage network status. Integration of AMR meters to the DMS has been in use since 2010. Supervisory Control and Data Acquisition (SCADA) and DMS systems have been integrated to provide automated fault location, -isolation, power restoration (FLIR) in medium voltage network without a Control Centre operator having to execute manually all the remote controlled switchings. FLIR has been utilized in all of Elenia's network since December 2011. A customer information system, a network automation system and a multichannel communication system have been integrated to provide customers with automated real-time customer specific outage information via an outage web map, free text message and e-mail services and interactive voice response service. [1] [2]

Elenia uses extensive partnership network of constructors which enables Elenia to achieve the targets set by the EMA. Elenia does not have own blue-collar workers on the field and instead purchases all of its electricity network services on the open markets and manages these partnerships with different agreements. These agreements cover electricity network construction, maintenance and fault repairing.

MAJOR POWER DISRUPTION MANAGEMENT

The national legal standard level for preparedness planning was set in the EMA in September 2013. The EMA states that every DSO must have a preparedness plan and that the National Emergency Supply Agency (NESA) will monitor and evaluate the quality of the preparedness plans. However prior to this this all the major DSOs have had preparedness plans in place for a over decade.

As the majority of Elenia's network is overhead lines and much of the lines are located in forests, weather conditions like low pressure storm systems, thunderstorms and heavy snowfall are the most common causes for major power outages. Elenia has a constant preparedness for major power disruptions and the Elenia's Control Centre monitors the status of the network and weather forecasts around the clock. Elenia has a secondary organisation called the "major power disruption organisation" with every employee having a role in it. [3]

Further development of major power disruption management at Elenia Oy is based on the experiences of 2011 Tapani and Hannu winter storms and 2013 Eino and Seija autumn storms. Each of these storms caused hundreds of simultaneous outages in the network. The target for the development projects was to minimize impacts of major power disruptions by faster power restoration to customers resulting in reduced number of outage compensation paid to customers and the regulatory outage cost as well as improved customer satisfaction.

CONTROL CENTRE OPERATOR COMPETENCE

The Control Centre plays a very important role during a major power disruption situation. An operator's effective fault handling, prioritization, and analysis work are crucial when facing a major storm situation. To achieve an even better performance, Elenia decided to increase the number of operators and upgrade the know-how in operative work.

Under normal circumstances the Control Centre operates in three shifts at all hours of the day. When facing a major storm or other exceptional situation the number of operators is increased. In those cases responsibility areas are determined for each operator. Areas are naturally smaller than in a normal operative situation and the operators' main focus is fault handling.

The main idea is to have two types of operators working in the Control Centre. To begin with, there are personnel whose main job is to work as an operator (level 1). Then there is a significant amount of personnel who work 1-2 times per month in the Control Centre as an operator (level 2) but their main job is something else. The former group consists of very experienced operators and the latter does not obviously have the same amount of practice. In normal operating conditions a level 2 operator always works with a level 1 operator. Level 1 allows a person to work alone. However, both groups are required to work independently in a major storm situation.

The development of Control Centre competence started with creating a two-level operator licence model. Level 2 was designed for a person who works as an operator in addition to one's own main job. Level 1 was designed mainly for permanent operators. However, it is in some cases possible to upgrade level 2 for level 1. This requires notable experience as an operator in the level 2 licence.

The licence for level 2 consists of certain formal qualifications, basic theoretical studies and practical training in the Control Centre. A comprehensive theoretical part was implemented with self-study and various induction sessions. The licence for level 1 involves all level 2 requirements. In addition it involves certain advanced studies and skills. Both levels also contain a final test situation before granting the licence.

The theory part of the licence 2 includes many basic themes. The outage management process is looked at as a whole in order to ensure same working methods and compulsory tasks. The main operative systems, operating with them and, for example, switching schedule designing are instructed. Substations, electrical protection, basic low and medium voltage network calculation and cooperation with contractors are also substantive themes. The theoretical part includes field visits to familiarize network objects. Customer service skills and matters related to confidentiality are rehearsed using examples.

Licence level 1 also has its own theoretical part. The idea was to concentrate on somewhat less frequent but serious situations that might occur. Level 1 has topics related to high voltage network calculation and the management of earth fault currents. Crisis situation communication, launching a major disturbance organisation and cyber security skills were also covered.

Practical training in the Control Centre was carried out alongside normal shifts. Permanent operators act as mentors for new operator candidates. One training session is either during a morning or evening shift in the Control Centre. In the beginning the candidate shadows the operator whilst he or she works. After that the candidate starts to work as a third operator and is monitored at all times by a permanent operator. It is the task of the third operator to lead planned outages, handle possible fault situations and take customer calls outside office hours.

A special simulation environment was used for training actual situations as an operator. The simulation environment consisted of virtual SCADA and DMS systems. Systems were linked between each other to simulate a real operation. The environment enabled both training and ensuring license competence with the final test situation. The licence for level 1 consists naturally of more challenging simulated situations than level 2.

The licence level 1 test situation comprises leading a planned outage and handling medium voltage fault situations. The idea is not to have routine cases in the test situation. Licence level 1 consists of recovery from an extremely severe fault situation in a high voltage network.

Compulsory safety procedures are evaluated in the test situation. The typical time for accomplishing a test situation is 3-4 hours.

An internal recruitment process was carried out for increasing the number of acting level 2 operators. Candidates had to have a background in electrical power studies. A tailored feasibility assessment for candidates was also carried out by an external third party. This psychological evaluation studied the candidate's cooperation skills, logical reasoning and especially stress management abilities. In addition, certain areas of health were inspected to ensure the person's ability to work as an operator.

Both licence levels 1 and 2 are re-verified every three years using simulated test situations. The electrical distribution branch is monitored and significant changes in the environment are evaluated. The idea is to develop operators' know-how constantly by modifying licence models when needed.

CONTROL CENTRE FACILITIES

Previously SCADA workstations located in the Control Centre and Operational Planning totalled at 13 pcs, so it was possible to have a maximum of 13 operators controlling the network simultaneously. When initiating the development project it was clear that the number of operators must be increased thus plans were made to increase the number of SCADA workstations from 13 to 21.

All the workstations were upgraded for new more ergonomic ones developed together with a Finnish furniture company. Workstations house eight 24" monitors in the Control Centre and six 24" monitors in workstations normally used by Operational Planning and Technical Customer Service. These additional workstations are used for network controlling in major power disruptions as all the resources are directed to restoring the power to customers.

Facilities were renewed and e.g. acoustics was improved via utilisation of sound deafening materials on the walls. Lighting and air-conditioning was improved to suit the increased number of workstations and people working in the Control Centre and supporting facilities.

NEW COOPERATION MODEL WITH FAULT REPAIRING CONTRACTORS

Elenia has different agreements for ensuring fault repairing resources from which the Elenia's annual frame contract is the most significant. In the annual frame contract Elenia's network area is divided into 21 separate regions which are managed by annual frame contractors who have the main responsibility for fault repairing works on the field.

The typical fault repairing process in the industry in case of medium voltage outages is as follows: Restoration of supply includes isolation of fault and restoration of electricity via back-up connections with network automation and remote controlled disconnectors executed by Control Centre operators. This is then followed by further isolation and restoration switchings in the field carried out by Elenia's contractor with a Control Centre operator managing the real time electrical status of the network and finally contractors execute safety procedures on location and initiate fault repairing. After fault repairing the electricity distribution is restored and the state of switching in the network is restored to normal. Typical process is presented in figure 1.

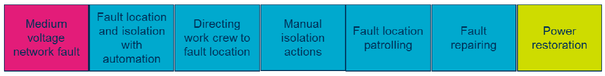

Figure 1. Typical process for fault repairing.

The development of the new cooperation model started from feedback discussions with several contractors after the autumn storms in Finland 2013. It was identified that the local knowledge of the annual frame contractors should be used more effectively in directing the fault location patrolling to the most probable fault locations. The annual frame contractors have the most detailed information about competence of their personnel, fault repairing equipment and availability of machinery. This information should be used to direct right resources straight to the correct fault locations and to prevent unnecessary redirection of field crews.

The planning of the pilot began in summer 2014 with main focus on large scale major power disruptions caused by low pressure storm systems or thunderstorms. The practical piloting of the model started in the beginning of 2015 with one annual frame contractor. First pilot experiences came January 2015 from a snow load situation for which the pilot model was not directly designed thus adjustments were made to the model during the situation. In spring 2015 there were several storms that reinforced the functionality of the concept and based on that the pilot was expanded to all of the annual frame contractors.

The cooperation model expands the responsibilities of annual frame contractors in fault resourcing and prioritizing. Contractors appoint the coordination personnel with their own areas of responsibility. All of the switching actions are executed centrally under the direction of the Control Centre.

The new model for fault repairing is presented in figure 2. The contractor's coordinators are independently managing the "Directing work crew to fault location" and "Fault location patrolling" partitions of the process thus resulting in a more efficient and faster execution of the overall process.

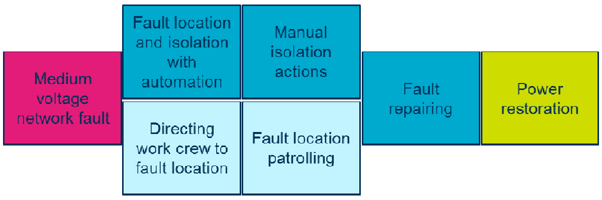

Figure 2. New cooperation process for fault repairing.

In the beginning of a storm the Control Centre focuses on the restoration of supply via the utilization of automation. At the same time the contractor's teams begin to patrol for fault locations while coordinators are documenting the fault locations directly to Elenia's DMS. The contractor directs the repairing resources to the right locations in the field.

The utilisation of this new model frees operator resources in the Control Centre to concentrate on the execution of network switching via remote controlled disconnectors and to the management of the electrical switching state of the network resulting in less of the electrician's time spent on non-productive work.

RESULTS FROM THE DEVELOPMENT INITIATIVES

As a result of operator competence development the number of level 1 and level 2 operators have been increased by 44% since 2013 with an increase of over 70% expected to be achieved by the end of 2016. The upgrading of Control Centre facilities enables the maximum utilisation of operator resources to minimize the impact of outages.

The use of the cooperation model enables a more effective use of the annual frame contractor's knowledge in major storm situations. Potential fault locations are possible to discover more rapidly in applicable cases by utilizing the areal knowledge. The model offers possibilities for the contractor to use information more effectively in the preparedness of resources. Thus allocations of resources correspond to the requirements of fault repairing. The contractor is also able to minimize the use of time by directing the nearest field crew to the fault location.
Additional improvements can be achieved by developing the operational IT-systems to support the cooperation model more productively. For instance information exchange between the Control Centre and the annual frame contractor can be intensified.

All of the development initiatives described in this paper have resulted in shorter interruptions for customers in major power disruptions, a reduced number in outage compensation paid out to customers and the regulatory outage cost and an overall more efficient and controlled management of the operation

SUMMARY

In 2014 Elenia initiated a development project consisting of the development of Control Centre operator competence, the renewal of Control Centre facilities and the development of new cooperation models with contractor partners.

Developments of Control Centre operator competence consisted of increasing the number of operators and developing the competence of individual operators. This was done by launching a new training program and creating a model for operator license. Control Centre facilities was renewed and the number of operator workstations were upgraded from 13 to 21 to enable dividing the network area for more operators so that the workload of an individual operator is at a manageable level.

The development of new cooperation model with contractor partners has made it possible to allocate responsibilities and tasks in a new way between Control Centre operators, contractor's areal field managers and field crews.

These development initiatives have resulted in a more efficient management of major power disruptions and improved service for customers.

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