COMMON GUIDELINES FOR RELIABILITY DATA COLLECTION IN SCANDINAVIA

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ABSTRACT

The paper presents a work that has been carried out in a common Scandinavian research project. The aim of the work was to establish common guidelines in Scandinavia for fault reporting, and to prepare the foundation for a Scandinavian fault database for voltage levels above 1 kV. The Nordel guidelines for reporting of disturbances above 100 kV are the most important basis for this work. The paper also discusses how users of a future database can be given access to the fault reports through the internet. The long-term goal of utilising component information in addition to the corresponding fault data through an internet database is also pointed out.

INTRODUCTION

Collection and application of fault and interruption data in the Scandinavian power system is done by different guidelines for each of the countries Norway, Sweden, Denmark and Finland. For voltage levels above 100 kV there are some harmonisation through the Nordel organisation, but for the MV level there is no common standard. In order to give the network companies (and others) a better decision basis for investments, operation, maintenance and renewal of the networks a common Scandinavian project called OPAL (Optimisation of reliability in power networks) was launched in 2002. The objectives of the project are:

- Development of common Scandinavian guidelines for collecting and reporting fault and interruption data
- Contribute to a better utilisation of fault and interruption data
- Development of methods for calculation and analysis of reliability of supply in power networks

One of the activities in the project has been to specify a common database for faults and interruptions. Considerable challenges for this work are the differences in detailing level between the countries and to a certain degree variations in the collected information historically. Similarities and differences between the countries were reported in [1], and together with the Nordel guidelines for classification of disturbances [2] this reference is the most relevant basis for the work. The aim is that a Scandinavian database in the future will be available for the data contributors (and possibly others) through the Internet.

There is different focus for the statistics in the Scandinavian countries. Norway has a focus on energy not supplied and corresponding costs, due to the CENS arrangement [3], while Denmark has the most detailed fault statistics on component level. Common for Norway, Denmark and Finland is that interruptions are reported at the MV/LV transformation level or at a HV connected customer, while in Sweden the reporting level is the LV customers. In Finland all interruptions are reported to the authorities, in Denmark interruptions >1 minute are reported, and in Sweden and Norway interruptions >3 minutes are reported to the authorities. In Denmark all reporting is voluntary and in Norway only fault statistics for MV distribution is voluntary. In Sweden and Finland a limited reporting of interruptions is compulsory and fault registration is voluntary [4].

In the paper we point out the differences and similarities in today's guidelines and systems, describe the first version of common Scandinavian guidelines [5], show plans for the development of a database that will be accessible through the Internet, and discuss various problems, challenges and possibilities in this context.

THE NORDEL GUIDELINES

The Grid Disturbance Group, organised under Nordel's Operations Committee, has developed guidelines for classification and calculation of disturbances, faults and energy not supplied (ENS) for the statistics published by Nordel [2]. These guidelines are first of all accommodated for transmission units with a system voltage above 100 kV, including units for reactive compensation.

The purpose of the grid disturbance statistics is to compile data that can form the basis of:

- A correct assessment of the quality and function of the different components
- A calculation or assessment of the reliability of the transmission system
- An assessment of the availability of delivery points
- Studies of trends and comparisons of different parts of the Nordel grid

The members of Nordel (Denmark, Finland, Iceland, Norway and Sweden) report grid disturbance data annually for the purposes mentioned above. For reliable statistics and possibility for comparison between the countries, it is important that definitions related to disturbances and methods for calculations are coordinated. If so, the quality of the data basis and the reliability of the statistics will increase. In this context the Nordel guidelines ensure that the countries are using the same basis for their reliability data collection, and this has been an obvious starting point for the work done in the OPAL project.

COMMON GUIDELINES FOR COLLECTING AND REPORTING OF FAULTS IN MV NETWORKS

While Nordel gives common guidelines for reporting disturbances in transmission grids with a voltage above 100 kV, research has proven [1] that there are many differences in the way faults and interruptions in the distribution (MV) grids are reported. This leads to problems when trying to use statistical data from more than one country in various analyses.

The existing fault information about MV networks is in many cases not precise enough for e.g. reliability analyses. To increase the number of components in the statistical base a set of common guidelines for collecting and reporting of fault data for the Scandinavian countries were developed.

An important aim of the new guidelines [5] is to get a far better basis for decisions concerning maintenance and investments in the grid. This makes it important to collect detailed information about e.g.:

- Manufacturers and types of the components
- Age of the components
- The environment in which the components are located
- The fault causes

Not all of this information is available in today's statistics. To get a comparable set of data it is important that interpretation of the guidelines differ as little as possible between countries and between companies. This can be very difficult to achieve, but work must continue with defining clear interpretations, especially in the borderline cases.

The guidelines cover faults leading to or exceeding disturbances, interruption consequences, all manual and automatic breaker operations due to faults, and replacement of fuses. The voltage levels covered are 1 – 100 kV, with the exception of generator transformers.

The guidelines do <u>not</u> comprise faults revealed by operation, fault localisation or maintenance, or faults on production equipment. Planned disconnections, response from protection devices, self-clearing earth faults and other temporary faults not leading to tripping of breakers, or normal replacement of wear parts are not included either.

The information that will be collected into a future Scandinavian database is shown in Table 1.

TABLE 1 – The content of a future Scandinavian fault database

Identification of the disturbance	
Event identification	Id number
Time of event	Date and time
Information about the fault(s)	
Fault number	Within the disturbance (1, 2, 3, etc)
Reference to disturbance	Reference to event id number
Network company	Chosen from predefined list of companies
Network area	Location of the fault picked from predefined list of areas
Component id *(optional)*	Unambiguous component id, picked from company specific list of components
Geographical location *(optional)*	Chosen from list defined by each company
Network type	Cable network (> 90 % cable), overhead network (> 90 % overhead line), mixed network (remaining)
Faulty component	Breaker, transformer, overhead line, cable, protection equipment, etc.
Component information	Manufacturer, model, capacity, year of installation
More component information *(optional)*	Type, function, placing, year of installation
Faulty sub-component *(optional)*	Specific choices for each component
System voltage	kV
Earthing system	Impedance, direct, isolated
Fault type	Earth fault, short circuit, open circuit, missing operation, unwanted operation, etc.
Primary or secondary fault	Secondary fault includes succeeding and latent fault
Fault character	Permanent, temporary, intermittent
Main fault cause	Specific choices grouped under lightning, other environmental causes, external influence, operation and maintenance, technical equipment, other, unknown
Underlying/contributing fault cause	Same choices as for the main fault cause
Repair time	Including fault localization
Repair type	Component replaced, permanently repaired, provisionally repaired, no repair
Information about the consequences	
Interrupted power *(optional)*	kW
Energy not supplied *(optional)*	kWh
Number of affected customers *(optional)*	Aggregated number for all affected customers
Number of affected DP *(optional)*	Aggregated number for all affected delivery points
Customer interruption duration *(optional)*	Aggregated time for all affected customers
DP interruption duration *(optional)*	Aggregated time for all affected delivery points
Total interruption duration *(optional)*	Time from first customer is interrupted to the supply is restored to the last customer
Disconnection type *(optional)*	Automatic, automatic with unsuccessful automatic reconnection, manual, none
Reconnection type *(optional)*	Automatic, manual, none

EXPLANATORY VARIABLES

Investigation of the explanatory variables for the occurrence of faults in power grids is also a part of the work in OPAL. To be able to make decisions on investments, renewal, operation and maintenance strategies it is important to have knowledge about the variables influencing the quality of the network.

First a broader separation of variables affecting the network can be made. Four different variables have been identified:

- **Climate**. The weather conditions in regions are often correlated with the faults.
- **Voltage level**. The type of equipment differs to a certain degree between the voltage levels.
- **Network structure**. The consequences of faults depend on the network structure (e.g. radial network).
- **Method of earthing**. The different types of earthing affect the behaviour of the network.

A table with a categorisation of each network company that constitute the data base, in accordance with the systematic described above, will be linked to the fault reports in order to make it possible to choose comparable companies and network areas for comparative studies or simply to enlarge the sample.

In addition, the utilisation of fault statistics is very often limited due to lack of information about the component population. In particular, this is evident in analyses where we need estimates of future fault frequencies for one component or a group of comparable components, e.g. in LCC analyses or maintenance and renewal evaluations.

Available fault statistics give limited possibilities for estimation of life distributions for components. Some of the main challenges are:

- Insufficient information about the age of the components.
- No information about the components that have not failed.
- The statistics are presented on an aggregated level (thus, only valid for repairable systems).
- Insufficient classification of component type, manufacturer, etc.
- There is an underlying assumption that all failures are independent.

For life distribution analyses more detailed fault statistics than available today are needed. One way of dealing with this problem is to link the fault reports with other data types, such as *inventory* data, *maintenance* data and information about *technical condition (state)*. With such links the analysts will be able to get more specific statistics sorted on various explanatory variables about the component, such as *manufacturer*, *type*, *age*, *operational conditions*, etc. If this information in addition could be standardised and collected into the Scandinavian database a large and valuable data basis could be established for very many planning and analysing purposes. The principles are illustrated in Figure 1.

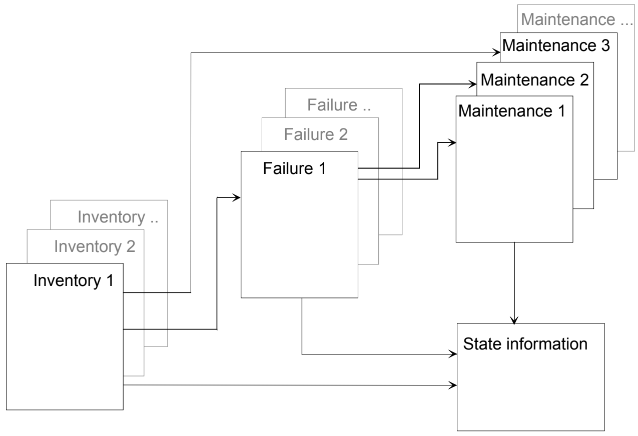

Figure 1 - Principle drawing of links between different data types as a basis for "producing" reliability data [6].

However, it is not realistic to establish such a reporting system on a short term, and the Scandinavian reporting format will not contain detailed inventory and maintenance data. Instead, some key information about the failed component will be included in the failure reports. But if we look beyond today's (or tomorrow's) solutions, a standardisation and linking between different data types as illustrated in Figure 1 will bring the potential for utilising reliability data a big step forward. Consequently, as a part of the research work carried out in OPAL we are trying to establish a foundation for a future standardisation of data and links between the different types.

WEB ACCESS TO THE DATABASE

Today, companies report disturbance data for distribution grids to the national statistics, and they put a lot of effort into this work. The statistics that are being published are predefined in accordance with the most common data needs. The statistics are based on the entire population, and are usually presented on an aggregate level. This means that the statistics are not necessarily customised and adjusted for each analysis. In the worst case, results of the analyses may lead to incorrect decisions because of maladjusted data basis. Since it is not possible to present all requested statistics in the publications, another solution is to make the data available for the users to define their own statistics. It is important to exploit the potential and possibilities that lies in such a database.

The internet makes it possible to make data available for every potential user. Through a future web site with functionality for database searches, a skilled user will be able to generate the statistics and parameters required for different analyses. This web site should for instance have functions for generating statistics based on whatever data that is representative for the requested reliability parameter. It should also be possible to compare selected grid companies, networks with similar external conditions, and components of same age and type, etc.

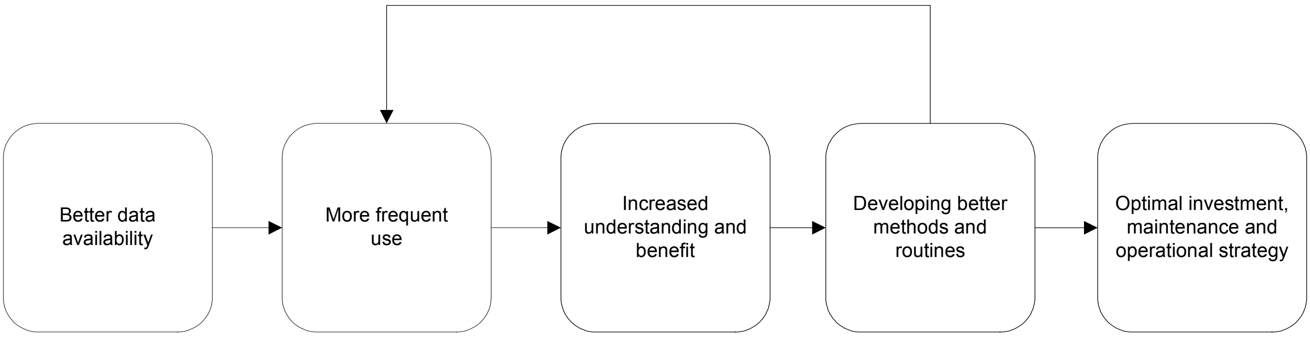

Figure 2 – Effects of better data availability and more flexible search facilities

When data is available in this way it is expected to have many positive effects. This can be illustrated as in Figure 2.

The harmonizing of disturbance data from the Scandinavian countries will make it easier to collect a bigger data basis. As a consequence, the component statistics will be more reliable. When this is up and running, hopefully in not a too far future, the Scandinavian grid companies will have a very good foundation for making reliable component statistics as basis for operation, maintenance and investment analyses. We are convinced that there is a large potential for increased profit by using more reliable input parameters in the economic analyses.

CONCLUSIONS

The paper has presented the work being done in the OPAL project where the aim is to establish common guidelines for fault reporting in the Scandinavian MV and HV network, based on the Nordel guidelines for voltage levels above 100 kV. As the work in the project is still in progress these conclusions should be considered as preliminary. However, some main points may be pointed out. We believe that there is a need for a larger and better data basis for decisions within the grid companies, as both the owners and the authorities are focusing on network efficiency and cost reductions. To cope with these challenges the companies have to justify the money spent on investments, reinvestments, maintenance and operation. In this context a solid fault data basis with user access through the internet will be essential. However, due to several circumstances this is not easy. The main challenge is probably the differences in today's registration schemes and the traditions between the countries. Changes in (to a certain degree) well-functioning systems and routines should not be done except for very good reasons. We believe that some of the differences may be eliminated through a national data adaptation before the data are entered into the Scandinavian database. However, some changes in the national systems and guidelines must be reckoned on.

It is very important to utilise information about the components and their environment as a supplement to the fault reports. We suggest a step-wise approach with the inclusion of some key information in the first phase, but with the long-term goal of having flexible links between several data sources, such as fault data, component information and maintenance data. This is without doubt a challenging, but indeed an important process.

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