Quality studies

The subject of quality of service to a power customer is often divided into the following quality dimensions, namely:

- reliability
- power quality
- provision of services

Reliability is related to the extent to which the power supply to customers is provided without interruptions. Disturbances in power plants and/or the network result in power failures once in a while. A 100% reliable power supply cannot be guaranteed.

Power quality is a term that is used to indicate deviations from the ideal sinusoidal alternating voltage. Examples of such deviations are voltage dips, frequency fluctuations and asymmetry between different phases.

Provision of services is concerned with the written, telephone and/or personal contact between the network company and its customers. Examples are connecting new customers, invoicing, and reacting to customer's questions or complaints.

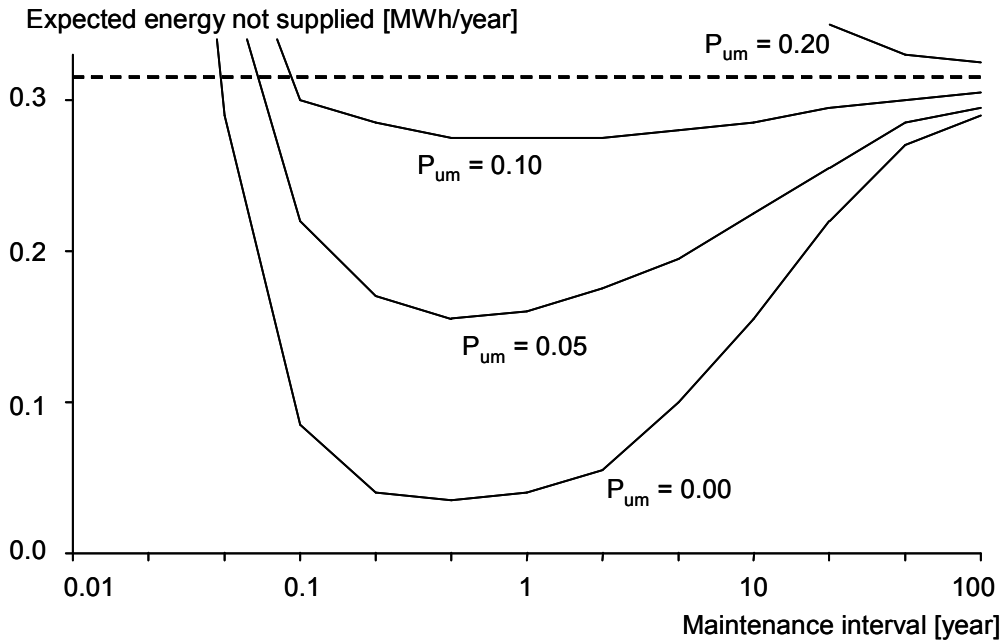
In this document, reliability as an aspect of quality is discussed a little further.

Reliability calculations for electricity networks

Within the network companies, the issue of the frequency for carrying out preventive maintenance is a hot topic. After a power failure occurs, questions regularly arise such as: "Can the costs of a power failure be reclaimed because the network company was negligent in maintaining its infrastructure?" Everyone can see on the one hand that it is possible to do too little preventive maintenance. On the other hand, it is also possible to do preventive maintenance too frequently. This is because, as is quite commonly known, failures are sometimes introduced when performing preventive maintenance. The arguments justifying the optimum frequency for performing preventive maintenance is therefore a difficult issue.

In the past, we deduced for a particular electricity network what the effects of the preventive maintenance interval were on the unavailability of the grid. It was assumed that maintenance activities were concerned with testing and revising protection relays and circuit breakers. The maintenance interval is expressed in years, and is depicted in the following diagram on a logarithmic scale. The unavailability is expressed in expected energy that is not supplied. The four curves in the figure have been determined for different values of the

probability of unsuccessful maintenance, Pum. The subscript “um” here means “unsuccessful maintenance”. The Pum values are also given in the diagram.



From the figure, it appears that:

- there is an optimum preventive maintenance frequency if the maintenance activities are performed carefully (small values of Pum);
- periodic preventive maintenance is pointless if the maintenance activities are not carefully performed (larger values of Pum);
- the optimum preventive maintenance frequency is equal to about two overhauls per year. This value is admittedly derived from a purely technical approach. The maintenance costs involved are not taken into account in the diagram;
- the curves in the figure converge to a value, corresponding to the situation in which periodic preventive maintenance is never performed.

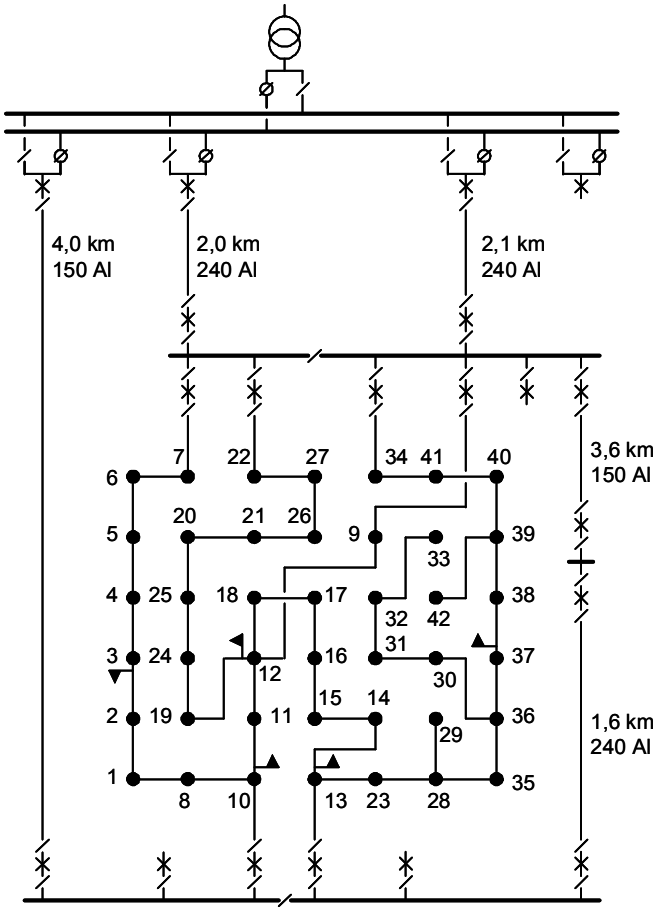
The reliability of power supplies is often described by the following reliability indices:

- interruption frequency [number of interruptions per year]
- average interruption duration [number of minutes per interruption]
- annual unavailability [number of minutes per year]

The annual unavailability is equal to the product of the interruption frequency and the average interruption duration. For an average Dutch customer at the low voltage level, the following values of the reliability indices currently apply (indices based on averages over the period 1999-2003):

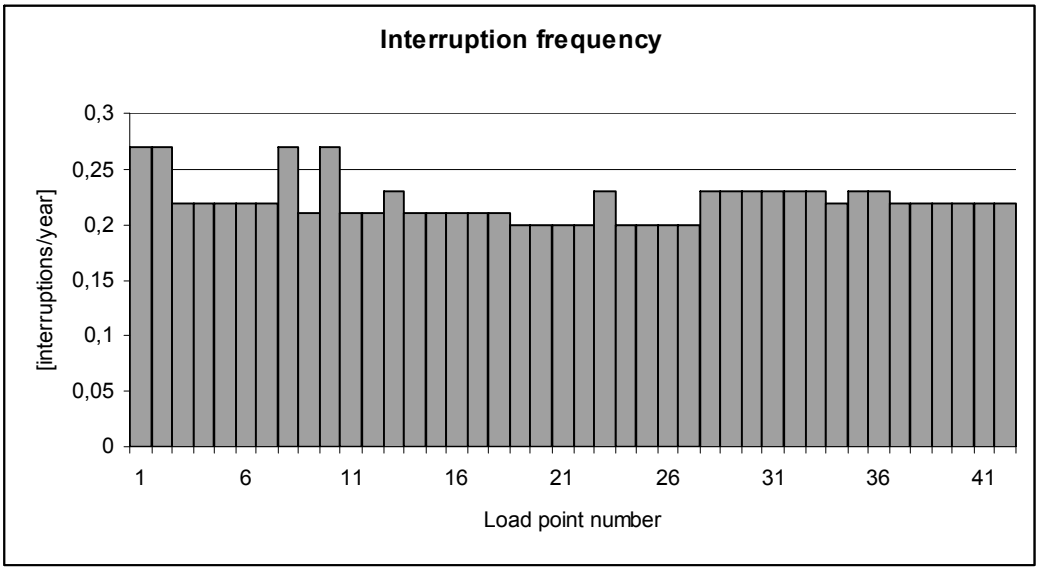
- interruption frequency: 0.38 interruptions per year, or a power failure once every 2.6 years
- average interruption duration: 75 minutes per interruption, i.e. when a power failure occurs, it lasts about 1 hour and a quarter
- annual unavailability: 29 minutes per year

Using calculation concepts and techniques that we developed, it is possible to perform reliability calculations for both existing network structures and for grid structures that are yet to be realised. An example is given below of the results of a reliability evaluation of an existing medium voltage grid. The grid structure is presented schematically in the associated figure. The network comprises a so-called meshed operated sub-transmission part and a radially operated distribution part. The network separations are marked with flags. The calculated interruption frequency and average interruption duration are given in the following two figures.

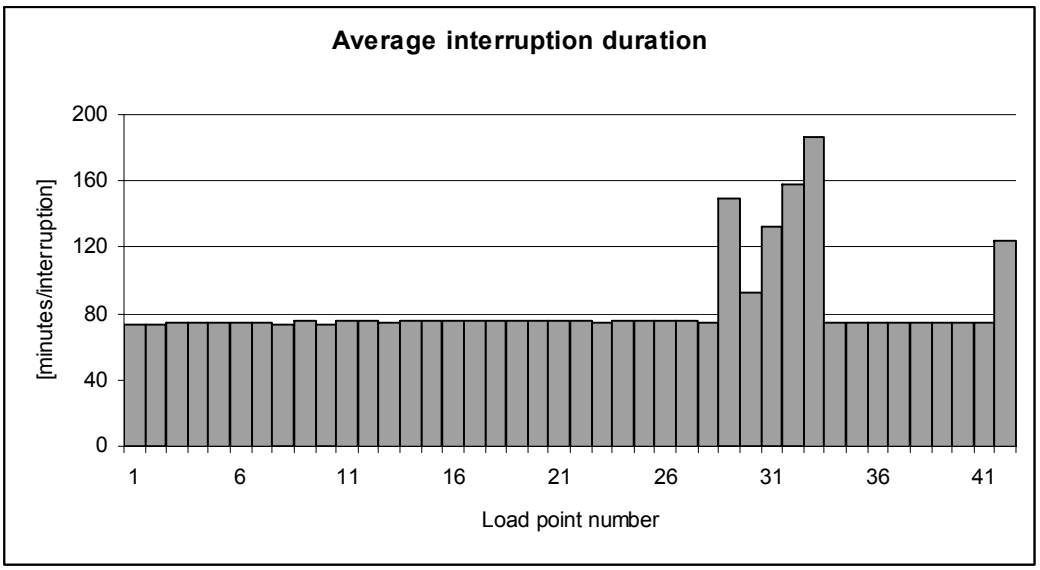


From the figure presenting the interruption frequency, it appears that six levels of interruption frequency can be distinguished. These levels correspond to the six radially operated distribution feeders in what is called the "one line diagram". For example, the load

points 1, 2, 8 and 10 appear to have the same interruption frequency, which would be expected since they belong to the same feeder. As the result of the long length of this feeder (which is not shown, incidentally), the interruption frequency of these load points is relatively high.



Additionally, the figure presenting the average interruption duration shows that feeders without a bypass capability have a higher average interruption duration. Some examples are the load points 29, 30, 31, 32, 33 and 42. The further the load point is located along in the feeder, the more the average interruption duration increases. This is due to the fact that the probability increases that the load point cannot be fed by an alternative path after performing switching actions.



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