RATIONALE FOR THE QUALITY OF SUPPLY POLICY; DETERMINATION OF QUALITY OF SUPPLY TARGETS

John Hodemaekers
ENECO NetBeheer – The Netherlands
J.P.Hodemaekers@netbeheer.eneco.nl

Theo Meeks
ENECO NetBeheer – The Netherlands
M.T.H.Meeks@netbeheer.eneco.nl

Floris Schulze
KEMA – The Netherlands
Floris.Schulze@kema.com

Gabriël Bloemhof
KEMA – The Netherlands
Gabriel.Bloemhof@kema.com

Harold Dijk
KEMA – The Netherlands
Harold.Dijk@kema.com

ABSTRACT
This paper describes how ENECO NetBeheer, a Dutch network company, determines its quality of supply targets and gives some insight how it is going to meet these. Quality of supply targets have been determined for HV, MV and LV networks related to several regions. To determine its quality of supply targets, ENECO NetBeheer has applied trend analyses, using a two years horizon to comply with the issue dates of its Quality & Capacity Document. Uncertainty has been indicated using confidence intervals. Targets have been decided and the remaining risk was estimated. To facilitate the development of measures to pursue the targets, performance indicators have been subdivided according to the type of faulted component and the causes of the initiating events. Improvement measures were focused on those causes that can be influenced by ENECO NetBeheer.

INTRODUCTION

Since 1st of December 2005, the Dutch Network companies have to submit every two years a so-called Quality & Capacity Document to the Dutch regulator (DTe) . In the quality part of this document the network company should give a forecast of its quality of supply of his network in terms of the well-known performance indicators SAIFI, CAIDI and SAIDI. The network company should not only give this forecast, he also should give a convincing explanation of how he will pursue his targets. By Ministerial Order it is required that Network companies should have a, preferably certified – not prescribed! –, risk based Quality Management System. By periodically auditing the Quality Management System DTe assures itself that Network Companies have created a firm base to realize their quality of supply targets specified in their biennially issued Quality & Capacity Document.

Since 1976 Dutch utilities are keeping outage data (ref. [1]). This data has now become official in that the DTe is using the performance indicators derived from these data to monitor the quality of supply in the Netherlands. Like the other Dutch Network Companies, ENECO NetBeheer provides its outage data to the de facto official outage database, called Nestor. ENECO NetBeheer has used its Nestor outage data, to determine its quality of supply targets. Targets have been determined for HV, MV and LV networks related to several regions.

We have applied trend analyses to determine the quality of supply targets. Based on data up to 2004, a forecast horizon of 2007 has been used, since this complies the issue dates of the Quality & Capacity Document. Uncertainty has been indicated using confidence intervals. Targets have been decided and the remaining risk was estimated. To facilitate the development of measures to pursue the targets, the performance indicators have been subdivided according to the type of faulted component and the causes of the initiating events. Improvement measures were focused on those causes that can be influenced by ENECO NetBeheer.

ENECO Netbeheer is more and more aware of the effects of fluctuations of the quality indicators. Using this statistic approach gives a better understanding if variations of indicators fluctuate within statistical boundaries or if they significantly indicate an effect of improved methods in outage restoration actions or the effect of new maintenance and replacement programmes. Statistical analysis is additional to the technical analyses of disturbances and their causes. Operational staff within ENECO NetBeheer has scrutinized the outcome of the trend analysis, using the Delphi method. Large discrepancy between statistical results and engineering guesses have been discussed and reconsidered to obtain a best estimate. This is particular the case for HV networks, since the amount of data is not always large enough to carry out sound statistical analyses. This approach has also proven its usefulness, since the measures to attain the targets have also been part of these discussions.

ENECO NETBEHEER

Eneco NetBeheer is one of the four largest Regional Network Operators in the Netherlands. It is subsidiary of Eneco Energie, an energy company that grew up from 1995 by mergers and take-overs of a total of eight utilities, the last one in 2003. Its grids are mainly in the western part of the Netherlands. The shaded area in Figure 1 shows the regions for which Eneco NetBeheer is responsible. ENECO NetBeheer is responsible for HV, MV and LV (150 kV

down to 0,4 kV) grids in these regions, i.e. it is accountable for the construction, expansion and maintenance of these grids. ENECO NetBeheer is also responsible for safety and reliability.

As a reaction of DTe's quality regulation and the requirement of issuing a Quality & Capacity Document every two years (starting in December 2005), ENECO NetBeheer has redesigned its reliability monitoring process.

Figure 1 Control area of ENECO NetBeheer

To monitor the reliability of its grids more closely, ENECONetBeheer has decided to analyse its outage data and the effectiveness of measures to improve its quality of supply performance more frequently and more transparently. Part of this monitoring process is a yearly base determination of its quality of supply targets, and the two-yearly issue of these targets to DTe.

APPPROACH

The reliability monitoring process improvement has started with:

- Central collecting of outage data by the Dispatch Centre
- Filtering of the outage data by eliminating blanks and extreme values, and further processing for statistical use
- Rearrangement of working environment: preparation of applying statistical methods

The applied method is trend analysis of year indices with a reliability interval. The trend analysis has been applied to the filtered outage data. A forecast horizon of two years (starting with a horizon of 2007) is used, since this complies with the issue dates of the Quality & Capacity Document.

Data Sources and data pre-processing

The base for the statistical analysis is the consolidation of the outage data of all (six) regions ENECO NetBeheer. Outage data from 1998 until now has been used for the statistical analysis. This implies that outage data before the merger and take-overs has to be harmonised: consolidated performance indices have to be determined.

The quality control of the outage data stored in Nestor has been intensified lately, since DTe uses this data for regulations purposes. KEMA, being an independent company, is carrying out the quality control by identifying and eliminating inconsistencies. This quality check has also been carried out retroactively, since the outage databases of the former companies of ENECO NetBeheer contain omissions, doubles and "odd" outages. As a result, this integral quality check yields the following improvements:

- A relatively great number of records for the LV level of the previous years has been removed: the related data was not complete enough for calculation purposes and had not been used for reports to the regulator earlier
- For similar reasons about 0,5 % of the outages at MV level has been removed
- Outages related to the HV level have not been removed: the related data did not contain peculiarities. Effected HV-customers were deleted however,, since they are not to be included in the data for the regulator.

For all outages the number of effected customers is totalled for LV and MV, including those from relevant underlying network operators. Nestor segregates levels of customers only since 2004. For LV-customers this does not make a significant difference. However, better data would have been better for MV-customers.

With the data cleanup it is secured that the database is filled with correct data, consistent with the current definitions. A crosscheck with the previous approved annual report showed that the result were of sufficient quality to perform the statistical analysis.

Quality of supply indicators

ENECO NetBeheer uses the following quality of performance indicators for its reliability monitoring process:

- SAIFI (System Average Interruption Frequency Index): It measures the average number of times per year that a customer is without electricity. It is obtained by dividing the total number of customers affected by an interruption by the total number of connected customers.
- CAIDI (Customer Average Interruption Duration Index): It measures the average duration of interruptions to supply for consumers that have experienced an interruption to supply in a year. It is obtained by dividing the customer minutes by the total number of consumers that have experienced an interruption to supply
- SAIDI (System Average Interruption Duration Index): It measures the average number of minutes per year that a customer is without electricity. Its is obtained by dividing the customer minutes by the total number of

connected customers
- CML (Consumer Minutes Lost): It is obtained by multiplying the number of effected customers by the outage duration.

ENECO NetBeheer monitors these indicators on a yearly base for its four control areas.

Selection of the statistic method

Many statistic methods and techniques assume a normal distribution of the underlying data. Equating the target value equal with the average value (often) is not enough. In fact, the average value is sensitive to (incidental) extreme values and does not take or hardly takes the underlying distribution of the data into account.

If the data is not normally distributed, other test methods should be applied.

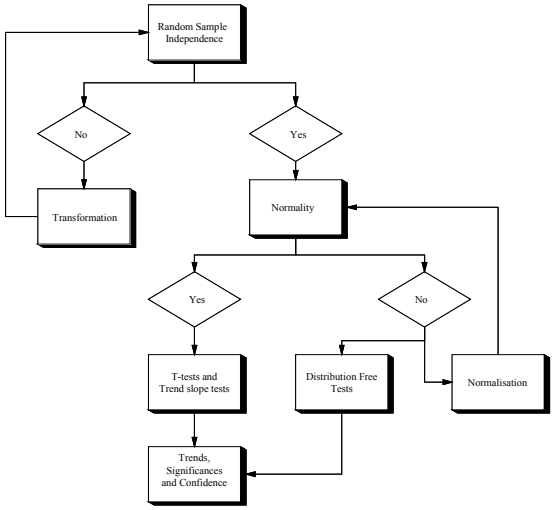

Figure 2 Selection of statistic method

Figure 2 shows the selection process that we went through to select the proper statistic method.

We have applied the so-called distribution-free tests to circumvent the problem of normality [2]. Distribution-free methods are methods for which the validity does not depend upon the underlying chance distribution of the observation. These methods often assume that the median is insensitive to extremes and that the underlying data is not necessarily normally distributed. A distribution-free test produces a single value as outcome. However, confidence intervals have been applied to obtain more insights in the trends.

Trend analysis

For reasons mentioned before (compliance with the issue date of the Quality & Capacity Document), a forecast horizon of 2007 has been chosen for the first project. It should be noticed that, depending on the quality improvement measures, effect would be apparent after two years or even more. Therefore, a forecast horizon of more than two years is not realistic: the effect of recently taken measures is not statistically handled.

In general the data handling process is as follows. First the raw data are used. The data is tested for extreme values (outliers) that may influence the trend in an unwanted or exaggerated way. If no outliers are detected, the so-called unweighted trend analysis is applied. On the other hand, a weighted trend analysis is applied when one or more outliers occur. In this case the outlier concerned, receive a lower weight, according to a certain statistic method described in reference [2]. The assignment of this weight is such that all data has more or less similar influence on the trend line.

The advantage of this approach is that it enables ENECO NetBeheer to obtain more insight in the degree of change in time. For this purpose, possible changes in the time are tested for significance: the range of a change is described statistically. The significance depends on the dispersion (fluctuations and extremes) in the data and the number of data that has served as a base for the trend analysis. Dispersion and the number of data determine the confidence interval in which future values can be projected. The more homogeneous the dispersion and the bigger the amount of data, the lesser the confidence interval, or in other words: the better future values can be forecasted.

In the analysis a confidence interval of 95% has been applied. The method provides solely numbers as a result; judgements are not given. Though the choice for 95 % is arbitrary, it is useful to know that it is the most applied value for this parameter.

RESULTS

Per control area and per voltage level (MV and LV) the following has been determined:
- The trend changes in time of the quality of supply indicators (SAIFI, SAIDI and CAIDI)
- The bandwidth that can be applied in determining the target values

This chapter pays attention to the some specific results obtained with the trend analysis. Due to space limitations only few results of the trend analysis will be discussed.

The final determination of the quality of supply target is a management decision, supported by both expert's experiences and the results of the trend analysis. Therefore, operational staff within ENECO NetBeheer has scrutinized the outcome of the trend analysis, using the Delphi method. Large discrepancy between statistical results and engineering guesses have been discussed and reconsidered

to obtain a best estimate. When observing the variations of the quality of supply indicators the central question is:

– do the variations fluctuate within statistical boundaries, or
– do the variations indicate an effect of improved methods in outage restoration actions or the effect of new maintenance and replacement programmes.

This approach has also proven its usefulness, since the measures to attain the targets have also been part of these discussions.

Trend analysis results

Figure 3 shows the outcome of unweighted and weighted trend analysis. It is seen, that in this case the unweighted and weighted analyses produced a similar trend. However, the confidence interval is smaller for the weighted analysis.

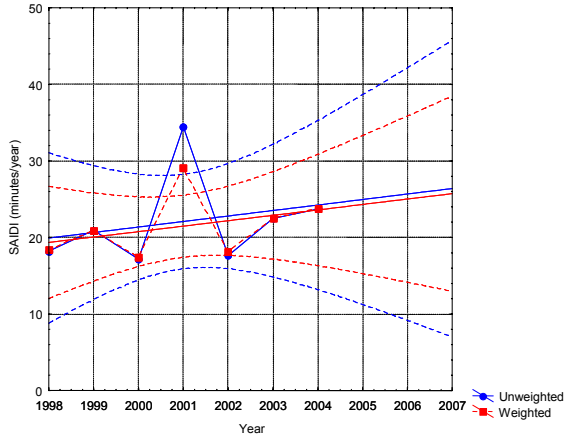

Figure 3 Results of trend analysis for SAIDI, MV level

The unweighted trend analysis produces the following outcome:

Expected SAIDI in 2007 (min/year):	26.4
Confidence interval:	
Lower Limit 95% expected SAIDI (-95%CL)	7.2
Upper Limit 95% expected SAIDI (+95%CL)	46.0

The following values have been calculated for the weighted analysis:

Expected SAIDI in 2007 (min/year):	25.7
Confidence interval:	
Lower Limit 95% expected SAIDI (-95%CL)	12.9
Upper Limit 95% expected SAIDI (+95%CL)	38.6

As the target for SAIDI in 2007 ENECO NetBeheer decided to choose the trend value 25.7.

Figure 4 shows a result for SAIFI at LV level. The apparent increase in 2003, after a small dip in 2002, has a very practical explanation. The intensity of the follow-up calls for the outage registration has been increased in 2003.

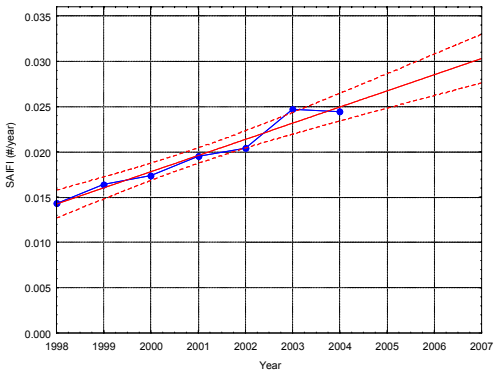

Figure 4 Results of trend analysis for SAIFI, LV level

Expected SAIFI in 2007 (#/year):	0.0303
Confidence interval:	
Lower Limit 95% expected SAIDI (-95%CL)	0.0276
Upper Limit 95% expected SAIDI (+95%CL)	0.0330

As the target for SAIFI in 2007 for LV in this region Eneco Netbeheer decided to choose the trend value 0.03.

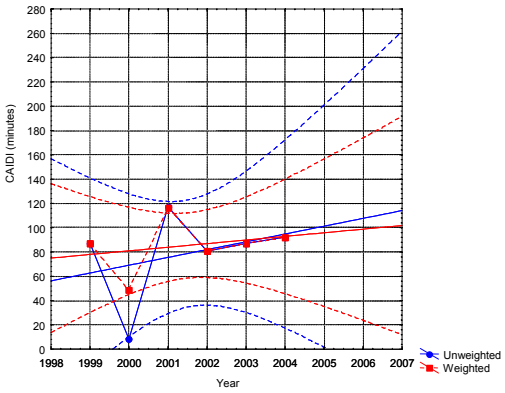

Figure 5 Results of trend analysis for CAIDI, MV level

Figure 5 shows a result for CAIDI at the MV level.

Unweighted expected CAIDI in 2007 (min)	113.5
Confidence interval:	
Lower Limit 95% expected SAIDI (-95%CL)	0.0
Upper Limit 95% expected SAIDI (+95%CL)	260.0

Weighted expected CAIDI in 2007 (min):	101.8
Confidence interval:	
Lower Limit 95% expected SAIDI (-95%CL)	11.2
Upper Limit 95% expected SAIDI (+95%CL)	192.4

As the target for CAIDI in 2007 for MV in this region ENECO NetBeheer decided to choose the trend value 101 min.

Obviously, in the discussion about the target values, their

feasibility has also been considered. This implies that the effectiveness of the measures to change the quality of supply has also played a role in establishing the target value. In a root cause analysis distinction has been made in causes that can be influenced (e.g. digging activities) and causes that cannot (e.g. soil activity). Costs and capacity as limiting factor has also been discussed. Moreover, 200 interruptions have been analysed in terms of proceeding time, complexity and accessibility to obtain better insight in factors influencing the interruption duration. These analyses have resulted in measures that have been recorded in the Quality and Capacity Document, and the annual plans of ENECO NetBeheer.

CONCLUSIONS

It has been described how ENECO NetBeheer, a Dutch network company, determines its quality of supply targets. ENECO NetBeheer has applied trend analyses to determine its quality of supply targets. Moreover, the discussed approach gives some insight in how ENECO NetBeheer is going to meet these. A two years horizon has been used to comply with the issue dates of its Quality & Capacity Document required by the Dutch regulator. A practical base for the feasibility of the statistically obtained target values has been obtained by applying a root cause analysis. Quality of supply targets and corresponding improvement measures have been incorporated in the Quality and Capacity Document, and the annual plans of ENECO NetBeheer.

REFERENCES

[1] G.A. Bloemhof, W.T.J. Hulshorst and Joh. Janssen, “25 years outage data, ready for the future”, Cired 2001, paper No.379

[2] Laan, van der, 1983, *Distribution-free methods,* University of Wageningen (In Dutch).

[3] D.C. Montgomery and E.A. Peck, 1982, *Introduction to Linear Regression Analysis*, John Wiley & Sons, New York.