INTRODUCTION

This report describes how the quality function is built up in the Swedish regulatory model and the views concerning its various parts that have been advanced from the network company Vattenfall EDistibution AB (Vattenfall). The report is concluded with a brief discussion of whether the quality function provides an incentive for quality improvements and of the weighting between the level of the network charge and the quality issue in the regulation.

THE REGULATORY MODEL

The Swedish regulatory authority introduced a new regulation of network tariffs during 2004. The regulation is based on a reasonable assessment of the tariffs. The term reasonableness relates to the company's revenue in relation to the costs of running the operations and to the way in which the operations are pursued. The assessment is based on a model - the network performance assessment model (NPAM) - that was developed over a period of several years. The model is described in more detail in a CIRED report from 2003 [1]. The model will be applied for the first time in 2004, and the application will relate to the 2003 network tariffs.

A fictitious network is created in the NPAM on the basis of input data consisting of X and Y coordinates, the voltage level and the energy consumption specified for all of the company’s customers. The cost of the imaginary network is calculated by means of the cost functions developed. The sum of all costs is the network performance that the company is considered to have achieved.

A quality addition is made to the network performance, which relates to an assessment of the company's way of running its operations. In the introductory stage, only power cuts will be handled in the quality function. In the longer term, other parts of delivery quality may be added to the assessment. The quality addition is calculated on the basis of the interruption statistics for the companies that are reported as input data.

Finally, a ratio - the debiting ratio - defined as the company's revenue divided by the sum of network performance and quality addition is calculated. According to the regulatory authority, a debiting ratio of more than 1.0 indicates that the network tariffs are not reasonable.

Debiting ratio = Revenue/(Network performance + Quality addition)

QUALITY FUNCTION

The quality function is the method that the regulatory authority uses for valuing how the network company pursues its operations. The quality function consists of a positive contribution (addition) from the Redundancy adjustment and a negative contribution (deduction) in the form of the Valued quality shortfall. The valued quality shortfall, in turn, consists of the Quality shortfall achieved minus the Expected (allowed) quality shortfall.

Quality addition = Redundancy adjustment - (Quality shortfall achieved - Expected quality shortfall)

The function has the limitation that the quality addition must not be negative, i.e. if the value of (Quality shortfall achieved - Expected quality shortfall) is higher than the value of Redundancy adjustment, the quality addition is taken to be zero. Another limitation is that the (Quality shortfall achieved - Expected quality shortfall) must not be negative, which means that quality that is better than expected does not give any extra addition beyond that obtained for expected quality.

Redundancy adjustment

The quality function in the NPAM is based on a pre-program for the ordinary NPAM. The pre-program is based on the assumption that all conductors and transformers in the radial fictitious network are assigned significant interruption frequencies and interruption times, divided onto faults or maintenance. The total interruption cost at every node in the network is thereby calculated as the sum of interruptions in the supply by the node, valued with the customers' interruption valuation for all customers downstream of the node who are dependent on the node for their supply. The customers' interruption valuation is calculated in accordance with the report produced by Swedenergy [2]. A sum of interruption costs for every node in the network is thus obtained. This interruption cost is compared with the cost of providing a reserve conductor or a reserve transformer for each node. If the cost of the reserve is lower than the total interruption cost of the node, the reserve is established in the network. It is then assumed...
that the total interruption cost in that particular node will cease.

When the calculations were made on the databases of a number of companies, the output data was used to give a density-dependent function of the redundancy adjustment for conductors per network level, and a power-dependent function for the reserve transformers per transformer type. The costs for all reserve plants calculated using these functions are known as the imaginary network's redundancy adjustment.

**Quality shortfall achieved**

The reported interruption values measured in SAIFI and SAIDI, which are the interruption frequency and interruption time, serve as the basis for the calculation of the quality shortfall achieved. These are valued with the customers' interruption valuation in accordance with Swedenergy. The calculation is carried out separately for scheduled and unscheduled interruptions in accordance with the following formula:

Quality shortfall achieved (Euro) = Frequency * P (kW) * (value1 + Time/60 * value2)

where

Mean power P(kW) = Energy(kWh)/number of customers/8760. Frequency is the interruption frequency. Time is the mean interruption time in minutes, value1 is the interruption valuation for the interruptions occurring in Euro/kW, and the value2 is the interruption valuation for switched-out energy in Euro/kWh. The table below gives some examples of the valuation-

<table>
<thead>
<tr>
<th>Unscheduled interruption</th>
<th>Euro/kW</th>
<th>Euro/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household</td>
<td>0,24</td>
<td>0,48</td>
</tr>
<tr>
<td>Commercial</td>
<td>4,04</td>
<td>20,07</td>
</tr>
<tr>
<td>Small industry</td>
<td>1,78</td>
<td>7,13</td>
</tr>
<tr>
<td>Mixed distribution</td>
<td>2,02</td>
<td>9,62</td>
</tr>
<tr>
<td>Scheduled interruption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household</td>
<td>0</td>
<td>0,24</td>
</tr>
<tr>
<td>Commercial</td>
<td>0,59</td>
<td>14,73</td>
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<tr>
<td>Small industry</td>
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<tr>
<td>Mixed distribution</td>
<td>0,34</td>
<td>6,77</td>
</tr>
</tbody>
</table>

The interruptions valuations for different customer categories are used to construct density-dependent functions for interruption valuation.

**Expected quality shortfall**

For a redundancy-adjusted network, the above mentioned pre-program for the NPAM has calculated how many interruptions and their durations an average customer will experience, measured in interruption minutes per year or in cent/kWh average costs after valuation with the customers' interruption valuation. The result is known as the expected quality shortfall. When these calculations were made for a larger number of companies, the results have provided the basis for density-dependent functions for the expected quality shortfall. These functions were then also entered into the NPAM. The calculation in the NPAM is done by multiplying the sum of energy consumption per network level (per voltage level) by a function for the expected quality shortfall expressed in cent/kWh for different densities.

Expected quality shortfall (Euro) = Energy (kWh) * function value (Euro/kWh)

The function values are obtained from density-dependent functions for different voltage levels in accordance with the following example for low voltage 0,4 kV (LV).

![Graph 1 Expected interruption cost](image)

**VIEWS ON THE QUALITY FUNCTION**

Vattenfalls views after analysing the different parts of the quality function are outlined below.

**Deduction for quality shortfall**

The redundancy adjustment functions in the NPAM specify the magnitude of additions in percent to the conductor lengths or transformers that are made at each network level. In simple terms, they thus describe the percentage addition to the new procurement value for each network level. The functions for conductors at 0,4 kV (LV) and 10 kV (HV) are the most important. They are drawn up in accordance with the following graph.
The graph shows that the redundancy adjustment is high in percentage on dense networks and gradually decreases for less dense networks. For higher network voltages, the functions are not density-dependent. Corresponding functions for transformers specify almost zero adjustment for network stations and 100% adjustment for transformation at higher voltages.

The additions vary widely between companies. Certain companies are allowed only a few percent, whereas others receive up to 25 - 30% redundancy adjustment. A deduction is made from the redundancy-adjusted network for quality shortfall. According to the definition, this deduction is limited to the redundancy adjustment.

The graph shows that the maximum deduction for quality shortfall in the NPAM varies widely between companies. Even if all companies had exactly the same quality shortfalls, certain companies would receive much higher deductions than others. The procedure means that the NPAM handles the companies differently, which is not acceptable. The view of Vattenfall is that the limitation of the deduction therefore should be changed.

Poor quality at low debiting ratios

It is open to question whether the NPAM should not be supplemented with a mechanism that motivates the companies to improve shortcomings in the delivery quality up to the expected quality, even for companies with low debiting ratios. It is not self-evident that the economic control signals in the model are sufficient, which appears inadequate from the customer's perspective. Vattenfall consider that the NPAM has not been fully developed in this part.

Limitation in the event of good quality

A company that has achieved quality that is better than expected probably faces higher network costs than what is justifiable from the national economy viewpoint. The company should perhaps not be compensated for the whole of this cost. On the other hand, such a company will have achieved a lower total inconvenience cost for the customer compared to the corresponding value at the expected quality. The company should then be compensated with a value that corresponds to the lower inconvenience cost. The view of Vattenfall is that the limitation condition in the quality function for such an addition should be removed.

Way of measuring the quality shortfall

The quality achieved by the companies is measured in the SAIFI and SAIDI values that describe the average interruption frequency and interruption time, broken down into scheduled and unscheduled interruptions. These values have the shortcoming that they are not dependent on the energy switched out on each interruption. These values are then valued with the customers' interruption valuation in accordance with Swedenergy which, for correct application, presupposes that there is a relevant energy specified in each interruption.

The calculation method described has three important disadvantages that must receive attention in the longer term if the quality is to be taken into account correctly in the model. The view of Vattenfall of these disadvantages are:

- that the energy consumption of an individual customer does not affect the reported value for quality when an interruption has occurred.
- that the interruption statistics do not take into account where the interruptions have taken place.
- that the interruption statistics do not take into account when the interruptions have taken place.

Quality shortfall valuation method

The interruption statistics reported by the companies are a compilation of all interruptions occurring during one year, broken down into scheduled and unscheduled interruptions. This naturally denotes that all customers have not had i.e. 0.5 interruptions for 150 minutes, but the reported values relate to an average for all customers in the region. The actual interruptions that have occurred have generally affected a limited number of customers, and these interruptions have been fairly long. Assuming that 25% of the customers have had interruptions, the duration of the interruption must be 10 hours to give an average interruption time of 150 minutes for all customers in the region. These 10 hours greatly exceed the 4 hours specified as the upper limit in the conditions for interruption valuation. Vattenfall consider that it is by no means self-evident that the existing interruption valuation reflects correctly the interruption costs for this group of customers.

Expected quality shortfall

A significant number of parameters are needed to describe fault frequencies and interruption times at component level in an electrical network. The values employed are naturally characterized by some uncertainty.
The view of Vattenfall is that shortcomings in the source information and calculation of the expected quality shortfall function are so large that the function cannot be regarded as reliable in its present state.

**SUMMARIZING VALUATION OF THE QUALITY FUNCTION**

The views of Vattenfall outlined above on the quality function in the NPAM together represent serious criticism of the design of the existing quality function. The criticism concerns the design of the individual parts rather than of the fundamental design of the quality function. The functions that make up the quality function must be designed in a responsible way so that balance will be achieved between the permissible revenue and the requirements of society for quality improvements. No such balance is provided by the present design of the NPAM.

It will be possible to make a further evaluation of the quality function in the NPAM when the regulatory authority has reported, for the first time, its calculations for all companies.

**BALANCE BETWEEN NETWORK CHARGES AND DELIVERY QUALITY**

Preliminary conclusions of Vattenfall concerning the NPAM in its present form is thus that insufficient priority has been assigned to quality. It has been possible to simulate the influence of change in quality by sensitivity analyses in different network areas. Improved quality has often proved to result in a very small change in the debiting ratio. The most important way for a network company to affect the debiting ratio will instead be to lower the network charge. The design of the model thus focuses on the charge level, whereas marginal significance is assigned to the quality issue.

Such a model would be reasonable if Sweden had high network charges and good quality compared to other countries. Various comparisons have shown that the opposite is true, namely that Sweden has low average network charges while, on the other hand, the delivery quality has proved to be lower than in many other countries.

In 2003 a comparative report of delivery quality in various countries was published [3]. The first graph below shows the interruption frequency (SAIFI), whereas the second graph shows the interruption time (SAIDI).

The graphs show that the delivery quality varies between different countries, and that it is lower in Sweden and the other Nordic countries and also in certain countries in Southern Europe than it is in Central Europe and the UK.

Various customer surveys in Sweden have also revealed that customers have become more sensitive to power supply interruptions and require better delivery quality.

Interruption valuation in accordance with Swedenergy enables the cost of interruptions to be valued in a simplified manner. A calculation was made of the interruption cost in the various countries, expressed as cent/kWh delivered energy, referring to a household customer with a yearly consumption of 5000 kWh. The result is shown in the graph below.

It is difficult to compare the network charges between different companies and countries. This is due to factors such as differences in distribution density (city, urban area, rural area), average energy consumption and various levels of customer service. In addition, the various countries have
different forms of taxes and charges, which also renders a comparison difficult.

Vattenfall has nevertheless found that, in the European perspective, the network charges in the Nordic countries are relatively low. It is therefore fundamentally wrong to have a regulatory model in Sweden that gives priority to low network charges in relation to improved quality. Many Swedish network companies are aware of this imbalance, but will still focus on improving delivery quality during the coming years in order to satisfy an expressed customer requirement. However, there is an obvious risk that the focus of the regulatory model on low network charges may put the brake on such quality improvement.

REFERENCES

