POWER QUALITY IN REGULATION OF DISTRIBUTION COMPANIES – A FINNISH CASE

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INTRODUCTION

The economic regulation of distribution companies in Finland is applied as a rate of return regulation. The Energy Market Authority in Finland has developed a new regulatory framework that has been in operation from the beginning of 2005. At present, power quality has only a minor role in this new regulatory framework and has no effect on the rate of return regulation. The Energy Market Authority has plans for including the power quality more intensively into the regulation framework and also to include it into the rate of return regulation. Some possibilities to take power quality into account in regulation from the regulator’s point of view are discussed in this paper.

GENERAL REGULATORY FRAMEWORK

The Finnish electricity sector was liberalised in 1995 when Electricity Market Act was established [1]. The purpose of Electricity Market Act is to ensure preconditions for efficiently functioning electricity markets by securing the sufficient high-quality electricity at reasonable prices. The primary means for this is to secure a sound and well-functioning competition in the production and sales of electricity and reasonable and equitable service principles in the distribution and transmission of electricity.

Energy Market Authority (EMA) supervises that the Electricity Market Act and any rules and regulations issued under it are complied with. According to the Electricity Market Act, the price of electricity distribution has to be reasonable, operation of distribution system operators has to be efficient and the power quality has to be in a reasonable high level. The market actors shall provide the EMA with any necessary statistical data and similar information for the appropriate handling of the tasks referred to in the Act of for the fulfilment of international commitments.

The regulation has previously been ex-post and due to the Directive 2003/54/EC the regulation in Finland has been replaced by the ex-ante regulation, where methodologies to be used to calculate or establish the terms and conditions for connection and access to networks are approved by the regulator prior to their entry into force. This reform of legislation introduced also regulatory periods of four years. However, the first regulatory period is three years from 2005 to 2007.

According to the Act the electricity network operation calls for a licence. It is granted if the applicant has the technical, economical and organisational skills needed for managing the network operation. The network licence granted to a distribution system operator specifies also the licence holder’s geographical area of responsibility. The distribution system operator has general monopoly to construct the distribution network within his area of responsibility. The Finnish network business is mainly carried out by private or municipal companies.

The Act considers the power quality issues in quite general terms. According to the Act the distribution network operator shall maintain, operate and develop its network and the connections to other networks in accordance with its customers’ reasonable needs, and to secure, for his part, the supply of sufficiently high-quality electricity to the customers. This requirement is called ‘obligation to develop the network’. In practice this requirement would mean e.g. that distribution network operator should take care of that the network is in good condition also in the rural area.

The Act considers also faults in power delivery. The supply of electricity is faulty if the power quality or the manner of supply does not correspond to what can be considered to be agreed upon. Unless otherwise agreed, the supply of electricity is faulty if the power quality does not correspond to the standards applied to in Finland or if there have been continuous or repeated interruptions in the supply of electricity, and these interruptions cannot be considered minor when taking into account their reasons and circumstances. On the basis of a fault, the user of electricity is entitled to the price reduction proportional to the fault or to compensation for damage suffered because of the fault. From the year 2003 the users of electricity are entitled to receive standard compensations for non-delivery of electricity lasting over 12 hours.

During the first regulatory period (between years 2005 - 2007), the regulation of power quality has an insignificant role but for the second period, starting in the year 2008, the role of quality issues could be strengthened in the network regulation.

PRESENT SUPERVISION OF POWER QUALITY

At present, the distribution companies deliver to EMA altogether ten key figures describing power quality. Eight of these figures have been collected since year 2003 on a voluntary basis. From the beginning of the year 2005 the delivery of these figures is mandatory. These figures are annual figures and they cover the total interruption time and the number of interruptions for the unplanned and planned interruptions. Also, the number of interruptions caused by the high speed and delayed automatic reclosing as well as the number of unplanned interruptions in the low voltage and medium voltage network is collected. The remaining two figures out of ten figures have been collected since the year
1996 and they consists of the annual average interruption time (including the planned and unplanned interruptions) and the annual average number of interruptions (including the delayed automatic reclosings) experienced by the consumer. These unweighted figures are based only on interruptions in the medium voltage transformer supply. These two figures correspond to the System Average Interruption Frequency Index (SAIFI) and the System Average Interruption Duration Index (SAIDI) described in the standard IEEE 1366-2001.

The detailed list of interruption data collected by the EMA is as follows:

**Power quality figures that have been collected since the year 1996**

Annual average interruptions for the consumer based on interruptions in the medium voltage transformer supply district. Figures are unweighted.

- Total interruption time (including planned and unplanned interruptions and delayed automatic reclosings)
- Number of interruptions (including planned and unplanned interruptions and delayed automatic reclosings)

**Power quality figures collected since the year 2003 [2]**

Annual average interruptions for the customer based on interruptions in the medium voltage transformer supply district. Figures are weighted with the annual energy consumption within transformer district.

- Total time of unplanned interruptions
- Number of unplanned interruption
- Total time of planned interruptions
- Number of planned interruptions
- Number of high speed automatic reclosing
- Number of delayed automatic reclosing

**Annual interruptions; figures are unweighted.**

- Number of unplanned permanent interruptions in a low voltage network (omitting the interruptions in the medium or the high voltage network)
- Number of unplanned interruption in medium voltage network (including the interruptions caused by the delayed automatic reclosing)

Total interruption time and number of interruptions are presented in figures 1 and 2 respectively. The figures present the average interruptions of all Finnish distribution companies since the year 1996.

The Finnish Electricity Association collects also interruption data and has an interruption data base that is to some extent more diversified and covers longer time period than the one EMA has collected. However, for the regulatory purposes EMA has the need for own figures which cover the interruptions in every distribution company and which can easily be used and modified for the various regulatory purposes.

Figure 1 and 2 present average interruptions of all distribution companies and also the interruptions when the companies are grouped as urban and suburban companies. The grouping of distribution companies into urban and suburban companies was realised by using the ratio of the medium voltage underground cables. If there are underground cables more than 30 % of the total medium voltage line length, the company is considered as an urban area company. In this grouping, the number of urban companies was about 30 out of total number of about 100 distribution companies. Because of mergers, the number of distribution companies changes from year to year. Between years 1996 and 2003 the number of distribution companies has decreased from 112 to 94. The structure of Finnish distribution companies is in many cases such that the company consists of an urban area, occupied fully by underground cables, and a suburban area around the urban area, occupied mostly by overhead lines. Thus the average ratio of the underground cables is not very high in most cases. The grouping of the companies to urban and suburban companies could be done by using some other ratio of underground cables or by using some other variable (for example the average line length for the individual customer) but it does not change the figures much. In any case the conclusions made from the figures remain the same.

**Deficiencies in power quality regulation**

Figures 1 and 2 show the average numbers of interruptions based on the data from all companies but EMA has also the numbers of an individual distribution company. With this data it is possible to evaluate the overall development in interruptions, compare the performance of an individual company with its performance previously and to compare the individual company with other companies alike. This implies that EMA can notice if there is a significant change in the
figures of an individual company or if something has happened that has an effect on many companies. For example in year 2001 occurred two storms, called Pyry and Janika, that were more extensive and stronger than storms usually in Finland. The consequences of these storms can be seen in the interruption figures of the year 2001.

Until the year 2005, the authority had only two figures in use as the other eight of the total ten figures, collected since 2003, were voluntarily collected and were not used for regulatory purposes. From the power quality regulation point of view, the problem with these two figures is that they do not show the power quality of an individual customer. This has caused problems when the authority has responded to quality complaints made by individual customers. Customers will usually contact their local distribution company when they have quality problems. If the company is unwilling to solve the problem or reacts too slowly, then customers usually make a complaint to the EMA. Usually the customer complains to the authority when there has been an unusually high number of interruptions or if the time of the interruptions has been disturbingly long. The authority receives also complaints when there are problems in a customer’s voltage quality; usually too low voltage or the voltage fluctuation is too high.

In these cases, as the normally collected quality data is not useful for analysing the situation, the authority will ask the distribution company under investigation to deliver more specific quality data for the authority. It is possible that the distribution company has to set up a special power quality metering session for detecting the quality problem announced by the customer and for being able to give a required response to the authority. If the power quality corresponds to power quality given by the standard SFS-EN 50160, the distribution company is not under obligation to pay compensations due to a low power quality. Even if the company has no obligation to compensate the low quality for the customer, it might have to take actions to improve its power quality. The EMA may obligate the company to improve the situation because the distribution companies have an obligation to develop the network. The EMA has not yet set instructions or limits for the distribution companies how the obligation to develop the network will be monitored. Obviously, the power quality will have an important role here.

According to the previous description, it is very clear that the average number of interruptions or the average interruption time are not adequate figures for describing the power quality for the individual customer. The situation cannot be improved much by adding a new set of figures if other figures than the average ones are not applied. The authority would clearly need a more detailed quality metering results from the individual customers, perhaps even from the worst served customers, to be able to make fair observations and justified decisions of the power quality situation in the distribution network. Metering the power quality, especially the voltage quality, from the individual customers so that the results could be used in the quality regulation, e.g. metering is done in indiscriminate way and so that all the customers are taken into account, is not easy. Perhaps the automatic remote reading technique combined with the electricity energy meters with power quality metering gives a solution for the problem.

One possibility to get the power quality under authority’s control is to use the power quality balanced and diversified in the network regulation. Next chapter describes that kind of power quality regulation.

POSSIBILITIES TO MONITORE POWER QUALITY IN THE FUTURE, A FINNISH CASE

The regulator has several possibilities to use power quality data in the network regulation. The first thing in the regulation is to define in what part of the regulation and how the power quality information could be used. The second thing is to develop the regulation in such a way that quality information can be used as a part of the regulation and organise the collection of relevant data.

Figure 3 suggests one possibility for the use of the power quality data in a Finnish regulatory framework. At the moment, the framework is under discussion within the EMA on a basic level. The framework presented here will be developed further and maybe changed significantly before it is accepted to be utilised in the network regulation in the second regulatory period.

Presently the Finnish power quality regulation is done case by case based on the complaints made by customers. From the beginning of the second regulatory period, in year 2008, the EMA is planning to use power quality data in the network regulation in a more versatile way than presently.

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Power quality, data and limits

The collected power quality data itself and the limits are the basis of the power quality regulation. The authority has to collect the relevant quality data and set limits for the individual quality figures. When determining what kind of quality data distribution companies have to collect and deliver to the authority, the authority has to make sure that the required data is possible to collect for every distribution company. Some of the quality figures are useful in the form they are collected and others can be used after some further calculations. As an example the interruption data can be used as a pure interruption time in the quality regulation, or it can be combined with the economic data and be used in form of the outage cost for the customer. Either way, the authority has to set limits for the pure interruptions or for the outage cost for the customer. Time limits and the amount of compensations for the standard compensations concerning longer interruptions have been set in the Electricity Market Act.

Rate of return regulation

The rate of return regulation consists of many parts such as definition of the asset base, calculation the return on equity and debt, setting the efficiency goals or the calculation of the risk level for the network operation. In this context it should be discussed how the power quality could be included in this framework or should it be included at all. The benefits to include the power quality in the rate of return regulation are obvious. In this way it is not possible for companies to compromise their network operations to a low power quality level and at the same time keep the profit on a high level. One possibility to include the power quality in the rate of return regulation is to include it in the evaluation of efficiency. In Finland, efficiency of the distribution companies has been calculated with the Data Envelope Analysis method (DEA) [3] and one of the DEA parameters has been the interruption time. During the first regulatory period DEA method is not used for efficiency monitoring and there is no power quality information involved in the rate of return regulation. For the second regulatory period there are plans to include the quality in the rate of return regulation. Whether it is done through efficiency regulation or otherwise and whether it is done in the form of the outage cost for customers or otherwise are to be solved.

Obligation to develop the network

Evaluation of the obligation to develop the network should lead to the economic optimal network structure and operation. In this evaluation investments and the power system quality can be considered. In assessment either parameters describing the quality of supply or trends in investments (either replacement or new investments) can be applied. If these two issues are used to produce a combined figure then the power quality has to be defined in the terms of customer costs, where the type of the customer and the annual energy should have an effect. Another approach is to evaluate these issues separately defining also levels of acceptable values (costs, amounts of interruptions, etc.) for each separately.

Network operators can select their network structure (e.g. meshed or radial operation, backup lines in radial network) and voltage levels. These issues have a great effect on the security of the power supply and investment costs. By investing the network company has to guarantee the power supply for the present customers and also for new customers. The age of the network components indicate the possible problems in the power quality. Comparing network components of different ages with average fault statistics it is possible to set a common level for the renewal of the components.

When power quality issues are considered the approach can be either to review interruptions or problems experienced by a single customer or average key figures describing the operation of the network company. It is possible that when average figures are considered the operation of the network operator has been on an acceptable level, but the quality problems experienced by a single customer have been on an unacceptable level. This leads to the conclusion that in the supervision of the network operation both approaches should be used.

Faults will always occur in the network, but when power quality is considered the severity of the faults should also be taken into account. The amount and duration of interruptions and amount and type of customers experiencing interruptions has an effect on the severity of faults.

The reliability of the information regarding the network operation, especially the interruption and fault statistics, plays a significant role in the assessment of the power quality and investment needs. When key figures and action limits are defined the time interval for the consideration is an important issue. The basis for the consideration is usually yearly key figures, but certain figures should be considered e.g. monthly, weekly or daily as standard SFS-EN 50160 defines. This enables that certain studies could be made in the connection of power quality measurements originating from customer complaints as part of the customer based power quality regulation. In defining key figures and their criteria it might be possible to apply also a regional classification. The origin of faults should be defined in more detail to give an input for the evaluation of the network investment needs.

Customer based power quality regulation

The customer based power quality regulation can and will be done in parallel with the regulatory periods. This means that the power quality has to be in a reasonable high level all the time. For the customer based power quality regulation the authority will get indications from the annually collected quality figures but also from the complaints of the customers. If the annually collected quality figures do not give adequate information, the authority can require the extra quality metering. The authority can set operational limits for the power quality so that if these limits are violated the network company has to take actions to improve the power quality. Obviously these limits have to be more strict that the limits for the compensation given by the standard SFS-EN 50160. The authority can oblige the network company to take actions to improve the power quality due to its obligation to develop the network.

SUMMARY

The paper presents the general regulatory framework and present situation in the power quality regulation in Finland. Here the supervision of power quality of an individual customer might be problematic because of average quality
figures collected presently. Especially complaints from the individual customer require extra measurements for quality purposes.

The power quality data can be applied in the network regulation in various ways. It can be applied either in the rate of return regulation or the customer based power quality regulation. It can be applied also when obligation to develop the network is considered. Here the balanced and diversified use of the power quality is the most important in the network regulation. It is also challenging because of combined effects on the network regulation when power quality is applied in various parts of the regulation framework.

REFERENCES

[1] The Electricity Market Act in Finland (386/1995), http://www.energiamarkkinavirasto.fi/ (also in English)
