NETWORKS

ESB Networks Response

to

ERGEG Consultation

on

Voltage Quality Regulation in Europe

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Distribution System Operator
ESB Networks

NSAI
I.S. EN ISO 9001

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I.S. EN ISO 9001

1.0 Introduction

ESB Networks recognises the vital importance of voltage quality to electricity customers. Ultimately the correct function of the customer's equipment depends on the characteristic of the voltage and the design of equipment. Standards such as EN 50160 are key in co-ordination of electricity system design and equipment design such that correct function is achieved and damage to equipment is avoided. ESB Networks welcomes the participation of the European Regulators in the standards development process. The consultation paper "*Towards Voltage Quality Regulation in Europe* " points to a number of aspects of EN 50160 which need to be addressed and represents an agenda for the review which is currently being undertaken by CENELEC. ESB Networks welcomes the opportunity to contribute to the process.

ESB faces particular challenges in relation to voltage quality. For a significant proportion of customers voltage quality does not conform to EN 50160 at the moment. Significant investment is being made to reinforce the networks so that voltage quality will conform to this norm. ESB is concerned that the limits on voltage variations in particular would be tightened. To conform to a tighter standard would require substantial extra investment. Ultimately such investment would need to be funded by customers and it is not clear that this is in the best interests of customers.

2.0 ESB Distribution System

ESB is the sole distribution network operator in the Republic of Ireland. Data on the number of customers and customer detail are provided below.

2.1 Number of customers and location

The population of the Republic of Ireland is approximately 4 million. The geographic area is 70,000 sq km. Overall the population density is one of the lowest in Europe.

An important characteristic for electricity distribution is that approximately 40% of the population live in the country side, outside of cites, towns and villages. Figure I below shows the population density

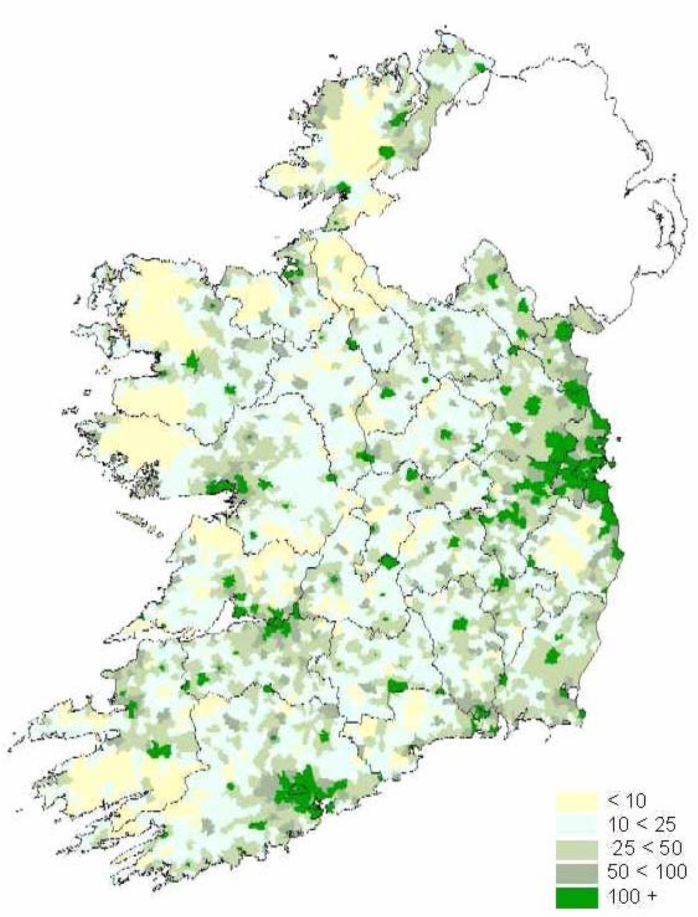

Figure 1. Population density of the Republic of Ireland

Most of the land mass has a population density of between 10 and 100 per square km with a substantial proportion less than 50 people per square km. In terms of electricity customers, the total number of customers at end of 2005 was **1.96 Million** and total GWh distributed in 2005 was **21,311 GWh**

2.2 Description of Distribution Networks

The distribution system in the Republic of Ireland which ESB Networks owns and operates contains 110kV, 38kV, 20kV, 10kV and LV networks,

The configuration of the Distribution System is illustrated schematically in Figure 2 below. Medium Voltage is either 10kV or 20kV

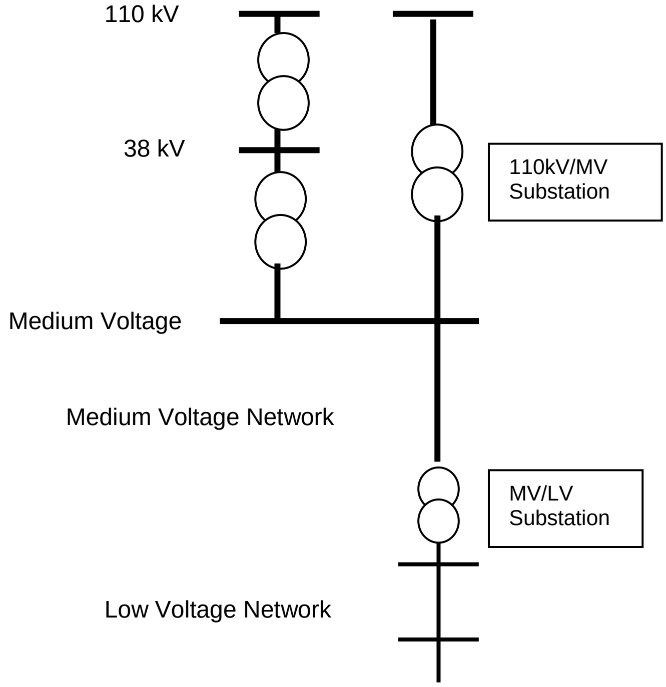

Figure 2. Representation of the Distribution System in Republic of Ireland

Key Statistics about the size of the ESB are given in Table 2 below:

Subtransmision		Medium & Low voltage	
110kV S/Stns		**MV Network**	
110/38kV	83	Overhead - 3 Phase	24,903
110/MV	21	Overhead - 1 Phase	53,915
110/38kV Tranformer capacity (MVA)	6,040	Cables	6,846
110/MV Tranformer capacity (MVA)	1,190	**MV/LV S/stns**	
38kV Network		Pole mounted - 3 phase	16,124
Overhead	5,633	Pole mounted - 1 phase	186,524
Cables	559	Ground mounted	15,781
38kV S/Stns		**LV Network**	
No. of Stations	430	Overhead	52,371
Tranformer capacity (MVA)	4,900	Underground	10,864

Table 2 ESB Distribution System at end 2005

The main feature of the ESB Distribution system is the huge extent of overhead line per customer. The reason is the high proportion of customers located in rural areas and the fact that these customers live in separate dwellings in the countryside rather than in villages and towns. Long lengths of line are needed to reach these customers.

To serve this rural customer base, ESB has adopted a system which is unusual in Europe. 38/MV substations feed radial 3-phase MV Overhead lines. Branch Lines consisting of two phase conductors are connected to the 3-phase line. These branch lines are referred to as single phase lines although they actually consist of two phase conductors. Near to houses, single phase transformers are connected to the single phase spur lines. These single transformers feed between 1 and 10 houses within a distance of approx 300m from the transformer. This design explains why there is so much single phase MV network and so many single phase transformers.

2.3 Voltage regulation in the ESB Distribution System.

The distribution system in the Republic of Ireland has been designed to deliver an LV Voltage of 244 – 207 under normal operating conditions. This is equivalent to 230V +6%, -10%

ESB also plans for an outage of a single item of plant at MV and higher voltages. The outage could be caused by a fault or could be to facilitate maintenance. This is referred to as an N-1 contingency. For networks supplying rural areas, the voltage is generally lower under such contingencies. For N-1 contingencies, the design target is 244V – 195V.

Scenario	**Target LV Voltage Range**	
	Volts	**% of Un (230 V)**
Normal Operation	244 – 207	+ 6% , -10%
N – 1 Contingency	244 - 195	+6%, -15%

Voltage at the MV busbars in 38/MV substations is maintained within a 2% bandwidth when the 38KV system is in normal configuration. The MV system is planned so that in normal configuration volt drop is limited to 5%. 3% voltage drop is allowed on the MV / LV transformer and 7% on the LV network. These allowed voltage drops total to 17%. However, assuming that the peak loads on the MV and LV network, will not coincide often, then the resultant voltage should comply with the requirements of EN 50160

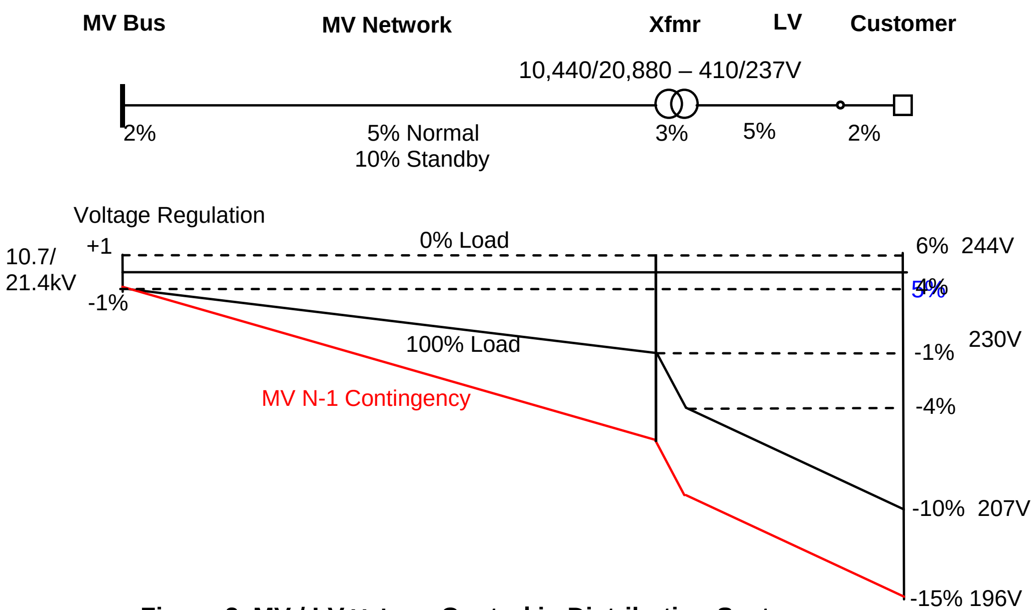

Figure 2 MV / LV Voltage Control in Distribution System

For an N-1 contingency on the MV system, an additional 5% voltage drop is allowed. With a base line of +6%, this means a delivered voltage of -15%. If the N – 1 contingency exists for a number of days, as it could if maintenance is being done or for a major fault, then voltage could be lower than -10%- for more than 95% of the time. As the current EN 50160 only requires the voltage to be within standard while the network is in normal configuration, this does constitute a non compliance

New houses continue to be built in the country side all the time and the number of house being supplied by the rural networks is continually increasing. Furthermore the average annual consumption is increasing. Customers are installing some apparatus with high demand e.g. electric showers. As a result, there is a substantial number (probably about 10,000 customers) whose voltage does not conform to standard with the network in normal operation. A much greater number of customers could receive a voltage lower than -15% for some N–1 contingencies especially at times of high load.

To improve this position ESB is currently in the process of converting the longer and heavily loaded rural overhead 10kV networks to 20kV operation. Also small single phase transformers (5kVA) are being changed to larger sizes (15 kVA minimum).

When individual customers complain of poor voltage, a recorder is installed to check for compliance with EN 50160. If it is determined that the voltage does not conform to EN 50160, then feeding LV network is reinforced. At the moment, between 1,600 and 1,900 non-conformances are being registered every year. ESB spends between €4 and €6M each year reinforcing LV networks in response to these complaints.

3.0 Responses to Recommendations to CENELEC for revising EN 50160

In this sections, ESB Networks comments on ERGEGs recommendations to CENELEC outlined in section 4 of the ERGEG consultation document

3.1 Improve definitions and measurement rules

ESB agrees that efforts should be made to improve definitions of some voltage quality parameters in EN 50160 and that international consensus on definitions is highly desirable.

3.2 Limits for Voltage Variations

As described in paragraph 2.3 above, ESB has designed its system to maintain LV voltage above -10% of Un (207V) in normal conditions and -15% in N- 1 contingencies. Meeting this objective is challenging because of continually increasing load on the networks. Substantial expenditure is being incurred to improve the networks to meet these criteria. ESB Networks view is that the -10% lower limit for normal network configurations should be retained.

As regards the application of the 95% of the time, ESB believe that some allowance must be made for the occasional coincidence of loads when measuring against the lower limit for voltage variations. Networks are designed based on statistical concepts presuming some diversity between customers load which is found to be acceptable in practice.

We do not believe that a requirement for voltage to be above -10% for **100%** of the time is in the best interests of customers. In ESB's case it would require more onerous design criteria which would lead to greater expenditure on new connections and on reinforcing the network. In practice most equipment functions reasonably well at voltages between Un -10% (207V) and Un -15% (195V). ESB Network's view is that customers would prefer to endure the very occasional reduction in performance of equipment rather than fund the extra investment that would be required to deliver voltage above -10% 100% of the time.

This point also applies to the **N-1 contingency** situations. In ESBs case, if it were required to ensure voltage is no lower than Un -10% for N-1 conditions, substantial investment would be required. We believe it would be necessary to reconductor 75% of the 3phase overhead MV lines system and 50% of the 38kV overhead lines. The cost would be in the region of **€700 M.** This is approximately €1,000 per customer located in rural areas. As the N -1 contingency arises only occasionally, ESB's view is that customers would prefer to accept the temporary reduction in equipment performance rather than fund this investment.

In relation to the **averaging interval**, ESB accept that in principle it may be appropriate to have an additional **upper** limit based on a shorter averaging interval than 10 min. in this case the limit should **be higher than +10%.**

The rationale is that voltage regulation equipment is normally set such that there is a delay before responding to voltage going outside target range. This is to avoid excessive number of tap change operations and consequential higher maintenance costs and reduced lifetimes. In the event of sudden changes on the transmission or sub-transmission system due to switching or tripping of load due to fault, a number of transformer tap changes may be required to bring the voltage back within target range. For example, the transmission grid code in Ireland allows an instantaneous voltage change in some circumstances of ±10%. The settings on voltage regulating relays are such that it would take 1 minute for the first tap change to occur and 1.5 minutes approximately to recover from such and event. So if customers' voltage was at +6% before the event, it would be at +16% for 1 minute before the tap change operations would restore the voltage to target range.

In deciding on what voltage limit should be associated with a shorter time interval, CENELEC should take account of what equipment can tolerate. We believe that in practice equipment can withstand higher voltages than UN +10 for short periods. This needs to be discussed with equipment manufacturers.

3.3 Extend the Scope of EN 50160 to high and extra high voltage systems

The necessity for European wide voltage quality standards at higher voltages where very few customers are connected is not clear. Voltage disturbances at HV will be reflected down at MV and LV. So, if voltage standards are set for MV and LV, this will require a network operator to ensure an adequate voltage quality at HV.

As there are different voltages in place in different countries, it may prove difficult to set limits that will have European wide application. In the case of voltage variations, the requirement for the HV system is determined by the tapping range of the transformers being supplied. This is probably different in different countries. In that case, there is no benefit in having European standards specifying limits for voltage variations at high voltage.

In countries where there are different system operators for distribution and sub-transmission systems, voltage quality standards for HV could have a role. It could prove more practical for a national regulator to set appropriate standards for its country rather than extending the scope of EN 50160.

3.4 Avoid ambiguous indicative values for Voltage events

ESB Networks agree that the first step is to agree a classification system for dips and swells. When that is agreed a monitoring programme can be started which could establish a base line level of voltage events in a given location over a number of years.

The characteristics of the networks are different in different countries and even in different parts of the same country. Consequently the profile of voltage events will vary with location. Ultimately it may prove difficult to set binding limits for voltage events that would apply across all of Europe.

3.5 Consider Duties and rights of all parties involved

ESB Networks agree that it is important to achieve a cost effective coordination between system related standards and equipment standards.

ESB Networks agree with the statement that it is useful to stipulate the minimum short circuit power being provided by a network operator. Minimum short circuit levels can be specified for a particular customer class based on the normal profile of equipment used by that customer class. If individual customers install unusual equipment which causes voltage quality disturbances, then the customer can be held responsible and be requested to bear the cost of the solution.

3.6 Introduce limits for voltage events

ESB Networks agree that limits for voltage events must take account of different network structures in the various countries and even within countries. i.e. overhead/underground, neutral grounding and short circuit power.

It may prove difficult to set limits for European wide application. An alternative approach would be to harmonise classification of voltage events and for national regulators to set targets for each of its regulated network operators. Which ever approach is adopted, it will be important to allow sufficient time to gather historical data to establish the present status.

4.0 Specific Questions on the recommendations to CENELEC for revising EN 50160

In this section, ESB Networks address some of the specific questions raised by ERGEG in section 7 of the consultation document.

4.1 What is the appropriate responsibility sharing curve between equipment and grid

ESB Network does not have sufficient expertise on equipment to answer this question comprehensively. It will require dialogue and exchange of information in the CENELEC working group. However ESB is concerned that significant weight is being given to the ITIC curve.

ESB believe that the ITIC curve was first developed in the 1970s when electronic equipment was powered via bridge rectified power supplies. We understand that most equipment nowadays has switched mode type power supplies. It is believed that switched mode power supplies can work on a much wider range of voltage.

4.2 What is the most appropriate way of protecting equipment against damage or failure due to short duration over-voltages.

A new limit should be set for short duration over voltages. This limit should be **higher than UN + 10**% to allow for the operation of voltage regulating equipment in the power distribution network. It needs to take account of the resilience of equipment in general use today.

4.3 Are there benefits further than customer protection important enough to justify reducing the range of voltage variations from Un ±10% to a narrower band.

There would be some savings in losses in adopting a tighter standard. However in most situations, the savings in losses would not offset the substantial extra capital expenditure required. The impact of tightening the limits would be to impose additional net burden on customers.

It would be inappropriate to try and enforce loss reduction by tightening the voltage standards. Other mechanisms are available to regulators to ensure that losses are taken into account when designing the networks.

4.4 How to consider random year by year variations in setting limits especially for voltage dips and other events correlated to weather

This is one of the difficulties in including binding limits for events which like supply interruptions are not entirely under the network operators control.

The best approach is probably to allow national regulators to monitor performance against specified targets with rules that allow adjustments for periods of exceptional weather. For simplicity, the smaller definitions of exceptional events should be used for interruptions and for voltage events.

4.5 How can power quality contracts be defined in order to focus improvements in voltage quality levels according to customer preferences

If definitions in EN 50160 are improved and monitoring programmes started with results published, customers with special power quality needs will be able to assess whether the voltage quality available at their site meets there need.

If a customer requires a higher quality supply than is generally available, they should be allowed to enter a contract with the network operator. The best approach may be to avoid stipulating the exact form of such contracts but rather to allow regulators to adjudicate in the event of dispute

5.0 GENERAL OBSERVATIONS ON THE REVISION OF EN50160 AND REGULATION OF POWER QUALITY

To conclude, we would like to make some general comments about the topic.

When contemplating any tightening of EN 50160 it is important to consider the costs to Network operators of achieving the new standard. The costs of resolving the co-ordination problem by making the equipment more robust must also be considered and the most economic solution adopted.

If it is ultimately decided to amend EN 50160, it is important that regulators take account of any extra costs on network operators. Networks operators could be faced with higher maintenance costs and additional capital expenditure if there is a tightening of the permitted voltage range and pressure to reduce perturbations of the supply.

Finally, ESB Networks recognise the increasing importance of quality of supply to its customers and the need to improve co-ordination of equipment and network design in order to meet modern customer expectations. We hope that we can make some contribution to the fulfilment of this objective and in particular we hope that our comments on the ERGEG paper will prove to be useful.