BENCHMARKING OF CONTINUITY OF SUPPLY

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ABSTRACT
At the end of October 2008 the Danish Energy Regulator Authority (DERA) made their first benchmark of continuity of supply in Denmark. The benchmark includes all Danish distributions system operators (DSOs) and regional transmission system operators (RTSOs) operating networks at voltage levels from and including low voltage distribution networks (230/400 V) and up to and including the 150 kV network. The benchmark is made in the light of the number of weighted customer interruptions in each DSO or RTSO area. For DSOs operation of low voltage and 6-25 kV distribution networks an extra benchmark is made in the light of the accumulated number of interruptions each customer is exposed to each year (worst served customers).

1. INTRODUCTION
In December 2004 the Danish Energy Regulator Authority (DERA) implemented the national departmental order BEK 1520 (Income cap regulation of DSOs and RTSOs). § 20 in this Danish departmental order says that from the financial year 2007 all DSOs and RTSOs should be benchmarked on economic efficiency and quality of supply.

Council of European Energy Regulators (CEER) has defined quality of supply as a combination of continuity of supply, voltage quality and customer service. However, voltage quality and customer service is at the time being (January 2009) not a part of the Danish benchmarking of quality of supply. This paper will therefore only cover the Danish benchmark of continuity of supply in the light of weighted customer interruptions.

2. THE GUIDELINES AND DATA SET
Since the late 1960s the Danish Energy Association has collected data of faults and interruptions in the HV network in Denmark to the EL-FAS statistics. With 50-years of experience highly specialised competences within faults and interruptions have been built up through the years. Therefore, when DERA in December 2005 published their guidelines for customer interruption registration, the guidelines were made with consultancy help from the Danish Energy Association R&D. The guidelines were supplemented with a collection of examples of fault and interruption registrations covering different examples of faults and interruptions.

Since January 1st 2006 all customer interruptions lasting one minute or more caused by faults or planned work in high voltage network have been registered. Since January 1st 2007 also all customers interruptions lasting one minute or more caused by faults or planned work in low voltage networks have been registered.

2.1 Delivery points and statistical areas
The Danish network has by tradition been divided into four statistical areas. These areas are:

- Low voltage
- 6-25 kV
- 25-70 kV
- 70-170 kV

Within each statistical area and/or between two statistical areas there are several delivery points. A delivery point is defined both geographically and technically. A geographically delivery point e.g. is between the DSO and its customer(s) e.g. a customer or another DSO or RTSO. The technically delivery point between two statistical areas is defined as the terminals at the low voltage side of each transformer.

2.2 Data in fault and interruption reports
The guidelines define the data which shall be collected. This includes data as:

- Report ID and personal ID
- Date and time
- Type (fault or planned work)
- Statistical area (in- or outside a statistical area)
- Reason (adv third part or force majeure)
- Number of interrupted customers
- Customer category (ordinary or special)
- Duration of interruption
- Notice (if the customers had been noticed about the interruption)

All these data is used to category each fault and interruption report. This categorisation is used in the following benchmarking of continuity of supply.

2.3 Key numbers for the benchmarking

2.3.1 Categorisation of reports
All faults and interruption reports are categorised before reporting the key numbers to DERA. The categorisation of customer interruptions is categorised in the following five causes:

1. Faults or planned work outside the statistical area
2. Force majeure within the statistical area (interruptions can be noticed)
3. Third party within the statistical area (interruptions
can be noticed)
4. Noticed interruption within the statistical area
5. Unnoticed interruptions/faults within the statistical area

Each year no later than March 31st each DSO and RTSO should report key numbers of customer interruptions to DERA. The key numbers is for the past year (January 1st to December 31st). The key numbers is reported on three schemes for each statistical area (only Scheme 1 is reported for 25-70 kV and 70-170 kV).

2.3.2 Scheme 1 (Average served customer)
This scheme is used for the benchmarking of the continuity of supply in the light of the number and duration of customer interruptions and average served customer experiences each year. The scheme and customer interruptions are reported in the five different causes as described in 2.3.1. From here the SAIFI/SAIDI values can be calculated.

2.3.3 Scheme 2 (End customer level, number/year)
This scheme is used for the benchmarking of the continuity of supply at end customer-level. At end customer-level the number of interruptions one customer (or a group of customers) experiences each year (in intervals from 0 to more than 10 interruptions per year) is reported i.e. worst served customers.

At end customer-level customer interruptions are only reported in two different report categories: Noticed and unnoticed customer interruptions. Both categories include all faults or planned work caused by faults or interruptions outside the statistical area, force majeure within the statistical area and third party within the statistical area.

Further, the schemes are reported separately for the LV (unnoticed and noticed) and 6-25 kV (unnoticed and noticed) statistical areas including faults and planned work in the LV network and 6-25 kV (incl. all high voltage) networks respectively. This means that a typically DSO shall report the following four schemes:

- LV, unnoticed
- LV, noticed
- 6-25 kV (all HV networks), unnoticed
- 6-25 kV (all HV networks), noticed

2.3.4 Scheme 3 (End customer level, duration/year)
This scheme is also used for the benchmarking of the continuity of supply at end customer-level (worst served customers). In Scheme 3 the duration of customer interruptions, that one customer (or a group of customers) experiences each year (in intervals from 1 min to more than 48 hours) is reported. As for Scheme 2 customer interruptions are only reported in two different report categories: Noticed and unnoticed customer interruptions. Further, Scheme 3 is reported separately for the LV and 6-25 kV network. This results in another four schemes.

However, Scheme 3 is not a part of the 2008-benchmarking because of an ambiguous paragraph in the guidelines.

3. THE BENCHMARKING

3.1 Main purpose
The DERA main purpose in benchmarking the Danish DSOS and RTSOs is to ensure a high level of continuity of supply. This purpose is obtained since the DSOS and RTSOs is being benchmarked on their economic efficiency and therefore have an incentive to reduce costs e.g. maintenance costs. All DSOS and RTSOs should therefore be given an incentive to reduce the number and the duration of customer interruptions within their network and their statistical areas. Therefore, in the 2008-benchmarking the incentive has resulted in a customer compensation, which may reduce a DSOS or RTSOs income cap up to 1.5% the following year.

3.2 Customer interruption weighting values
Before benchmarking the DSOS and RTSOs, their key numbers is being weighted. The weighting values are as listed in table 1:

<table>
<thead>
<tr>
<th>Category</th>
<th>Weighting value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faults or planned work outside the statistical area</td>
<td>0 %</td>
</tr>
<tr>
<td>Force majeure within the statistical area (interruptions can be noticed)</td>
<td>0 %</td>
</tr>
<tr>
<td>Third party within the statistical area (interruptions can be noticed)</td>
<td>0 %</td>
</tr>
<tr>
<td>Noticed interruption within the statistical area</td>
<td>10 %</td>
</tr>
<tr>
<td>Unnoticed interruption/faults within the statistical area</td>
<td>50 %</td>
</tr>
</tbody>
</table>

Table 1. Weighting values for report categories

All customer interruptions which affect customers in the category “Special” are weighted 0 %.

3.3 Benchmarking – Average customer level

3.3.1 Threshold values
For each statistical area DERA has determined threshold values for the number and the duration of the weighted average customer interruptions per year. All threshold values are based on two-years data reported in 2006 and 2007 (only 2007 for LV). To each DSOs and RTSOs weighted SAIFI/SAIDI value in 2006 and 2007 the quantity of network within the DSOS or RTSOs respective statistical area is linked. Within each statistical area all DSOS or RTSOs is ranked from the lowest weighted SAIFI/SAIDI value to the highest. The threshold value for each statistical area is then determined as the 80-percentile of the total quantity of network within the statistical network with the lowest weighted SAIFI/SAIDI value. If the 80-percentile is between two DSOS or RTSOs values a linear interpolation is made to determine the 80-percentile threshold value. Figure 1 shows the principle in the determining the weighted SAIFI threshold value for the 6-25 kV area. All threshold values are listed in table 2 and 3.
Figure 1. Principle for determining the weighted SAIFI threshold value for the 6-25 kV statistical area.

Table 2. The DERA threshold value for DSOs and RTSOs weighted SAIFI values.

<table>
<thead>
<tr>
<th>Weighted SAIFI Statistical area</th>
<th>Threshold value</th>
<th>Mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>6-25 kV</td>
<td>0.58</td>
<td>0.34</td>
</tr>
<tr>
<td>25-70 kV</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>70-170 kV</td>
<td>0.07</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Table 3. The DERA threshold value for DSOs and RTSOs weighted SAIDI values.

<table>
<thead>
<tr>
<th>Weighted SAIDI Statistical area</th>
<th>Threshold value</th>
<th>Mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV</td>
<td>10.82</td>
<td>5.61</td>
</tr>
<tr>
<td>6-25 kV</td>
<td>29.13</td>
<td>16.57</td>
</tr>
<tr>
<td>25-70 kV</td>
<td>4.06</td>
<td>2.47</td>
</tr>
<tr>
<td>70-170 kV</td>
<td>0.90</td>
<td>0.63</td>
</tr>
</tbody>
</table>

The threshold values are at the time being not fixed but may be changed in the next benchmarking in 2009 as more data and more reliably data is available.

3.3.2 The benchmark model
In the light of the threshold values the final benchmark model is determining whether the DSOs and RTSOs had secured its customers an acceptable continuity of supply or not. This is done by comparing and individually threshold value with and individually weighted performance SAIFI/SAIDI value.

In the benchmark model all DSOs and RTSOs will be corrected if a DSO or RTSO has a higher quantity of network in one (or more) of the interruption ineffective areas. The 6-25 kV statistical area is in the light of the threshold values the most interruption ineffective area. This correction is done by weighting the threshold values and performance SAIFI/SAIDI with the percentage of network in each statistical area in the light of the DSOs or RTSOs quantity of network in total. Table 4 shows a case study with a DSO network data.

Table 4. DSO case of individual network and weighted performance SAIFI value.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LV</td>
<td>1.000 km</td>
<td>50 %</td>
</tr>
<tr>
<td>6-25 kV</td>
<td>800 km</td>
<td>40 %</td>
</tr>
<tr>
<td>25-70 kV</td>
<td>200 km</td>
<td>10 %</td>
</tr>
<tr>
<td>70-170 kV</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sum</td>
<td>2.000 km</td>
<td>100 %</td>
</tr>
</tbody>
</table>

The individual benchmark threshold value for the DSO case study =

LV network in % x LV threshold value + 6-25 kV network in % x 6-25 kV threshold value + 25-70 kV network in % x 25-70 kV threshold value + 70-170 kV network in % x 70-170 kV threshold value =

50 % x 0.07 + 40 % x 0.58 + 10 % x 0.15 = 0.282

Compared to the individual weighted performance SAIFI value for the DSO case study =

50 % x 0.08 + 40 % x 0.45 + 10 % x 0.20 = 0.24

This determine, that the DSO in the case study had an acceptable level of continuity of supply in 2007 (0.24 < 0.282) despite that the DSOs weighted performance SAIFI in the case study exceeded the threshold values for the LV (0.08 > 0.07) and the 25-70 kV (0.20 > 0.15) statistical areas. The formula is the same for calculating the SAIDI.

3.3.3 Customer compensation
DSOs and RTSOs with an unacceptable continuity of supply for the average served customer in 2007 had to reduce their income cap by 1 % the following year.

3.4 Benchmarking – End customer level
DSOs may ensure an acceptable level of continuity of supply for the average served customer, but still have a group of worst served customers. The benchmarking at end customer level is applied to determine if a customer (or a group of customers) is exposed repeatedly to short or long interruptions.

In the 2008-benchmarking the benchmarking of end customer interruption duration (Scheme 3) is not included because of an ambiguous paragraph in the guidelines. As a consequence of this, DERA is at the moment (January 2009) considering the calculation of end customer interruptions.

End customer interruption data is only available for one year (the year 2007).

3.4.1 Threshold values
A DSO has an acceptable level of continuity of supply at end customer-level if no more than 1 % of all customers experience more interruptions than the threshold values determine as acceptable. However, the threshold values for
end customers interruptions in the LV and the 6-25 kV statistical area is determined by identifying the number of interruptions that 99,5 % of all customers experienced in 2007 caused by faults or planned work.

Table 5 shows the threshold values for the benchmarking at end customer-level (worst served customers).

<table>
<thead>
<tr>
<th>Number of interruptions</th>
<th>LV (incl. all high voltage networks)</th>
<th>6-25 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>98,0 %</td>
<td>87,9 %</td>
</tr>
<tr>
<td>1</td>
<td>1,6 %</td>
<td>8,5 %</td>
</tr>
<tr>
<td>2</td>
<td>0,3 %</td>
<td>2,5 %</td>
</tr>
<tr>
<td>3</td>
<td>0,1 %</td>
<td>0,7 %</td>
</tr>
<tr>
<td>4 or more</td>
<td>0,0 %</td>
<td>0,2 %</td>
</tr>
</tbody>
</table>

Table 5. Threshold value for the number of customer interruptions in the LV or the 6-25 kV (incl. all high voltage networks) statistical areas (worst served customers).

3.4.2 The benchmark model
The DERA 2008-benchmark model of continuity of supply at end customer-level (worst served customers) is very complex. Therefore, this paper does not leave the space for an underlying description of the model. However, the benchmark model includes the four schemes as mentioned in 2.3.1. These four schemes are weighted two-and-two – firstly, with respect to the interrupted distribution in the light of Scheme 1, secondly, with respect to the interruption category (see 3.2).

3.4.3 Customer compensation
DSOs with an unacceptable continuity of supply at end customer level in 2007 had to reduce their income cap by up to 0,5 % the following year. The income cap reduction is weighted in the light of the distribution of the total DSOs network in the LV and 6-25 kV statistical area.

Table 6 shows the principle for determining the DSOs income cap reduction.

<table>
<thead>
<tr>
<th>Customer share above threshold value</th>
<th>LV</th>
<th>6-25 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity of network [in km]</td>
<td>1000 km</td>
<td>800 km</td>
</tr>
<tr>
<td>Quantity of network [in %]</td>
<td>55,6 %</td>
<td>44,4 %</td>
</tr>
<tr>
<td>Customer compensation (Income cap reduction)</td>
<td>0,5 x 55,6 % = 0,28 %</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 6. Case DSO determining the DSO income cap reduction as a consequence of benchmarking of end customer-level (i.e. worst served customers).

As regards to the benchmark of average served customers Danish Energy Association finds, that DERA had made an model error, when weighten the DSOs and RTSOs weighten SAIFI/SAIDI with respect to the quantity of network in each statistical area. Therefore the quantity network weightening must be left undone. However, still a DSO or RTSO may be allowed to exceed a threshold value for one statistical area, as long as the sum of all statistical area threshold values for which the DSO or RTSO is operating network at is not exceeded.

Finally, all threshold values must be fixed for a longer period of time than until the next year.

CONCLUSION
The Danish Energy Regulator Authority (DERA) made in October 2008 their first benchmarking of DSOs and RTSOs continuity of supply including a benchmark of average served customers and end customers-level (worst served customers) in Denmark. The benchmarking includes all voltage levels from low voltage to 150 kV networks which make this benchmark quite unique.

The Danish Energy Association finds that the 2008-benchmark models with respect to average served customers and worst served customers are defective and too complex.

REFERENCES


DANISH ENERGY ASSOCIATION’S POSITION

The Danish Energy Association respects the facts that the departmental order BEK 1520 says that all Danish DSOs and RTSOs shall be benchmarked on economic efficiency and quality of supply. – However, a benchmarking of continuity of supply must be as simple and reliable as possible. That is not the case regarding the 2008-benchmarking. The Danish Energy Association has sent several letters and documents to the DERA for consideration in respect to the 2008-benchmark of continuity of supply. However, DERA has only in very few fields been willing to change their benchmark. Therefore the Danish Energy Association has sent a letter of complain regarding the DERA 2008-benchmark to the national complaints board in November 2008. In January 2009 this complaint is still in hearing.