INTERRUPTION DATA AT INDIVIDUAL CUSTOMER LEVEL - EXPERIENCE FROM SWEDEN 2010-2011

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ABSTRACT

All Swedish network operators annually report data on the continuity of supply for their customers, to the Energy Markets Inspectorate, the national regulatory agency. Starting with the reporting period (1 January – 31 December) 2010, continuity of supply information has to be provided for each individual customer. Further distinctions are made between short (less than 3 minutes), long (3 minutes through 12 hours) and very long (longer than 12 hours) interruptions; planned and unplanned interruptions; and interruption due to events in the local and in other grids. Data for 2010 and for 2011 has been received and analyzed.

This paper presents some of the additional information that can be obtained by having access to data at individual customer level, and discusses some further experience with this scheme.

INTRODUCTION

Electricity has become more and more important to the society. In cities or in rural areas, people use modern technology which depends of electricity. That is why a good continuity of electricity supply is paramount for each customer.

In 2010 a new regulation came in force on reporting data for assessing the continuity of supply [1]. Since 2010 all Swedish distribution system operators (DSO) have to report interruption data for every individual customer. This data is collected and analysed by the Energy Markets Inspectorate (Ei), the Swedish national regulatory authority. This paper presents some of the early experience on the gathering and analysis of this data, with emphasis on local distribution networks.

REPORTED INTERRUPTION DATA

The Swedish DSOs (”local network operators” as explained below) are reporting per customer the annual consumption of electricity and the fuse size, subscribed power, or equivalent. The reporting also includes the transformer that supplies the customer and the customers’ SNI 2007 code (The Swedish Standard Industrial Classification Index), which corresponds to NACE rev. 2 (Nomenclature Generale des Activites Economiques dans l'Union Europeenne - European industrial activity classification). Because SNI 2007 is a classification of industries, Ei has developed a special code for household customers and another for connection (boundary) points to other grids.

The interruptions are divided in notified and non-notified interruptions. There notified interruptions are treated in the statistics and in this power as planned interruptions, all other as unplanned interruptions.

For planned interruptions, the DSOs report the number of interruptions and the total interruption time (minutes) for each customer.

The unplanned interruptions are divided in interruptions up to 12 hours and those longer than 12 hours. For each class, the DSOs report the number of interruptions and the total interruption time for each customer. Furthermore the DSOs have to report the number of short interruptions [2] for each customer. In all cases a distinction should be made between interruptions due to incidents in the grid owned by the reporting DSO and interruptions due to incidents elsewhere. A general requirement for reporting is that the reported data has to be of good quality [3].

The availability of all this data gives the possibility to analyse the reliability of the grid in a new manner. Now the regulator can see if a grid’s general indexes as SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) are alike for all the grid’s customers or if there are customers who are suffering of a lower continuity of supply.

In Sweden the public electricity network is divided in approximately 168 local grids, 6 regional grids and one transmission grid. The operators of the local grids have a concession for a certain geographical area and they are responsible for connecting customers within their concession. The regional grids operators do not have an area concession but instead a number of line concessions. The regional grids connect the local grids with the national transmission network (at 220 and 400 kV). Also large customers (consumption and production) are connected to the regional grid when a connection to the local grid would not be practical. There are no voltage levels related to the division between regional and local networks, but in practice most local grids operate voltage levels to 20 kV and regional grids voltage levels between 40 and 130 kV.

For local grid companies, the continuity of supply is typically quantified by indicators like SAIFI and SAIDI. The availability of data at individual customer level makes it possible to have other indexes like CEMI (Customer Experiencing Multiple Interruptions) and CELID (Customer Experiencing Long Interruption Durations) [4]. For short

interruptions indices like MAIFI (Momentary Average Interruption Frequency Index) can be used. A similar analysis is possible for regional grids, the difference is that for those grids system indexes as AIT (Average Interruption Time), AIF (Average Interruption Frequency), ENS (Energy Not Supplied) and PNS (Power Not Supplied) are more commonly used.

DATA COLLECTION

When Ei started the study on reporting of interruption data at individual level, most network operators were able to collect and report data at customer level. During the first year, when the new regulation came in force, there were some problems among others with the data-collection software used by the NRA (national regulatory authority) but also with the data collection and reporting by the DSOs. This was partly due to incorrect interpretation of the details of the regulation but also due to network operators using no or not suitable software for recording their interruptions. Especially during the first year of reporting, the NRA had to request many DSOs to resubmit the data. The second year saw less such problems.
Some examples of initially incorrectly reported data are: net reporting of energy consumption (for customers who had both consumption and a separate subscription for feeding power back into the grid); some customers with negative energy consumption; customers without or incorrect SNI 2007 code; too many companies without a single short interruption.

Because of these data gathering and reporting problems, the statistics cannot be trusted for all individual network operators. However we have no indications that this has resulted in large errors in national indicators. Also are the errors not larger than when only SAIFI and SAIDI per DSO would have been reported. The availability of data at customer level gives the NRA the possibility of doing a quality assessment of the data and request corrected data from the DSOs. This has in fact been the case with several DSOs during 2010 and 2011.

Where it concerns the reporting of short interruptions, the impression is that there are large gaps in the data. Too many DSOs report no short interruptions at all. This might be a consequence of their way of operating the network, but it may also be due to technical problems in gathering data on short interruptions. The data collection on short interruptions will continue but no statistics are being presented over 2010 and 2011 because they were not deemed as sufficiently reliable.

CONTINUITY OF SUPPLY INDICES

Number of Interruptions

The number of unplanned long interruptions per customer (SAIFI) originating in the local grid over 2011 over the whole of the country was equal to 1.32. The number of interruptions varied however strongly between customers. Figure 1 shows that nearly 45 % of the customers in Sweden did not have any unplanned interruption during 2011, but it also shows that almost 4% of the customers had four unplanned interruptions.

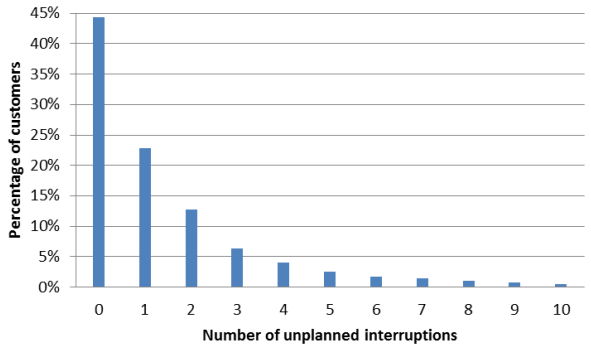

Figure 1 Distribution of the number of unplanned interruptions in 2011 for all customers in Sweden

The same data also shows that 56% of the customers have had at least one long unplanned interruption and 14 % (729 603 customers) of the customers have had at least four long unplanned interruptions (see figure 2 below).

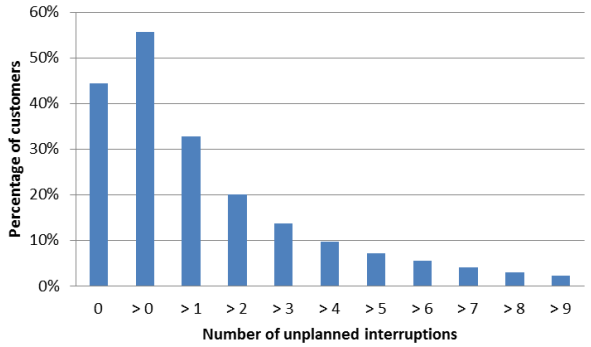

Figure 2 Percentage of customers who surfed of "n" or more unplanned interruptions in 2011 for all customers in Sweden

Customer types

Individual customers are not identified in the reporting other than by their subscribed power, their annual consumption and their SNI 2007. If the data is grouped by SNI 2007, then one can see that customers who belong to the category "agriculture" are the ones most affected by the interruptions. That group has a SAIFI on 3.3 and a SAIDI on 394 minutes. The continuity of supply for customer types according to SNI 2007 is shown in Table 1 and 2.

Table 1 Average number of unplanned long interruptions for different customer types

Customer types (SNI 2007)	Number of customers	SAIFI
Agriculture	34 141	3.3

Industry	75 073	1.6
Trade and Services	370 556	1.3
Public activities	108 971	1.7
Domestic	4 711 998	1.6

Table 2 Average unplanned long interruption duration for different customer types

Customer types (SNI 2007)	Number of customers	SAIDI
Agriculture	34 141	394
Industry	75 073	165
Trade and Services	370 556	121
Public activities	108 971	165
Domestic	4 711 998	190

Relation with classical indices

The data also shows that a DSO can have customers who are suffering of a much higher number of interruptions than the system index SAIFI shows.

Attention should be paid to Table 3. For example, DSO number seven has a SAIFI of 3.85, but 99.9% of its customers suffered at least 4 unplanned interruptions and 10% of its customers suffered 12 or more interruptions. Note that SAIFI has been calculated on unplanned interruptions due to events in the DSO's grid, while the percentage of customers who have had at least 4 or 12 interruptions is calculated base on all interruptions a customer had suffered during the year. In the case of DSO number seven which has a SAIFI of 3.85, one can see that 99.9% has also suffered of at least four interruptions which is the result of interruptions caused by incidents outside of the DSO's grid.

Table 3 DSOs with most interruptions per customer (SAIFI) in 2011

	SAIFI	Number of customers	Percentage of customers who have had at least 4 interruptions	Percentage of customers who have had at least 12 interruptions
Sweden	***1.32***	***5 303 646***	***25.1%***	***1.4%***
DSO 1	6.53	26 532	74%	38%
DSO 2	6.34	1 529	62%	43%
DSO 3	4.65	1 503	94%	8%
DSO 4	4.6	113 805	53%	17%
DSO 5	4.22	1371	54%	0%
DSO 6	3.88	80 326	45%	7%
DSO 7	3.85	831	99.9%	10%
DSO 8	3.12	967	99%	0.1%
DSO 9	3.1	2 401	63%	0.04%
DSO 10	3	520	0%	0%

The same analyse is possible to do for SAIDI. Table 4 shows e.g. that DSO number four has a SAIDI of 898 minutes, but none of its customers had 4 or more interruptions, while DSO seven with a SAIDI of 515 minutes has customers (53%) who had during 2011 suffered at least 4 unplanned interruptions and 17% of its customers suffered at least 12 interruptions. The calculation of SAIDI and the percentage of customers who have had at least 4 or 12 interruptions are based the same as for Table 3.

Table 4 DSOs with the longest SAIDI in 2011

	SAIDI	Number of customers	Percentage of customers who have had at least 4 interruptions	Percentage of customers who have had at least 12 interruptions
Sweden	***174***	***5 303 646***	***25.1%***	***1.4%***
DSO 1	1 535	26 532	74%	38%
DSO 2	1 433	1 529	62%	43%
DSO 3	1 086	80 326	45%	7%
DSO 4	898	520	0%	0%
DSO 5	758	98 539	31%	0%
DSO 6	545	3 942	17%	0%
DSO 7	515	113 805	53%	17%
DSO 8	510	7 015	2%	0%
DSO 9	460	2 401	63%	0.04%
DSO 10	443	3 636	26%	0%

Comparison between 2010 and 2011

As the DSOs report in accordance with the regulation that came in force 2010, EIFS 2010:5, it is possible to compare the continuity of supply between 2010 and 2011 at different levels. Averaged over the whole country the number of unplanned long interruptions due to incidents in the local grid, was equal to 1.0 over 2010 and equal to 1.32 over 2011.

Table 5 shows the average number of the interruptions for different groups according to the SNI 2007 codes. One can also see that the number of interruptions to the group agriculture (rural customers) is higher in 2010, as well as in 2011, than for other customer types.

Table 5 Average number unplanned long interruptions for different customer types

Customer types (SNI 2007)	2010	2011
Agriculture (01110-03220)	2.6	3.3
Industry (05100-43999)	1.2	1.6
Trade and Services (45110–82990, 94111–96090)	1.0	1.3
Public activities (84111-93290)	1.3	1.7
Domestic (111111, 97000–98200)	1.3	1.6

One can also see that, the Swedish customers have had more interruptions in 2011 compared to 2010. See Table 6.

Table 6 Percentage of customers in Sweden who suffered at least "n" unplanned interruptions during 2010 and 2011

	2010	2011
at least 1 interruption	50%	55.6%
at least 4 interruptions	10%	13.8%
at least 10 interruptions	2%	2.3%
at least 15 interruptions	0.5%	0.7%
at least 20 interruptions	0.2%	0.3%

CORRELATION BETWEEN INDICATORS

Two examples of the kind of analysis possible with the data collected are shown in Figure 3 and Figure 4.

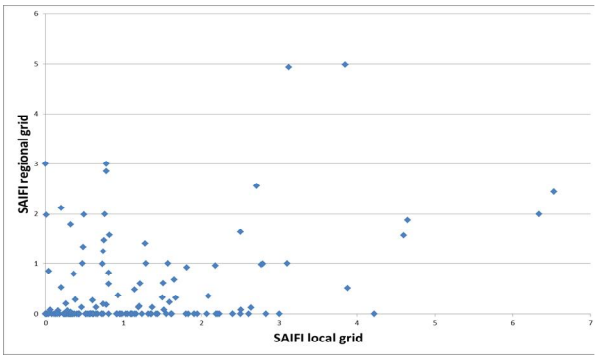

Figure 3 SAIFI, for unplanned interruptions, due to the events in the region and local grid

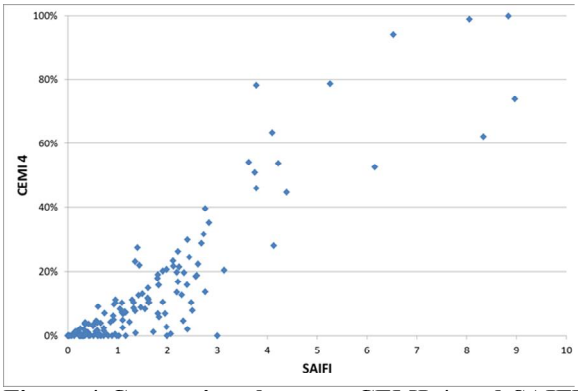

Figure 4 Comparison between CEMI 4 and SAIFI for unplanned interruptions

Figure 3 shows that there is only a mild correlation between the number of interruptions originating in the local network and the number of interruptions originating in the regional network. There are points below the diagonal (majority of interruptions from the local network) as well as above the diagonal (majority from the regional network).

Figure 4 shows that there is a rather strong correlation between the average number of interruptions (SAIFI) and the number of customers experiencing four or more interruptions per year (CEMI 4), especially for low SAIFI values. However for SAIFI above 1, the spread in CEMI 4 becomes big, so that the latter gives important additional information on the continuity of supply.

CONCLUSIONS

This paper has presented the data the DSOs reported to Ei for assessing the continuity of supply. The reporting of interruptions per customer gives a lot of information which can be analysed and gives a more complete picture of different customer groups, even down to the specific customer regarding the continuity of supply. Example of it is that some companies with relatively low SAIFI have customers who experience 12 and more interruptions per year; that in some cases, the number of interruptions caused by faults in the overhead grid is higher than the number of interruptions caused by faults in its own grid.

ACKNOWLEDMENT

This paper contains the personal opinions of the authors and not necessarily the opinion of the Energy Markets Inspectorate.

REFERENCES

[1] EIFS 2010:5 The Swedish Energy Markets Inspectorate regulations and general recommendations concerning the obligation to report outages to assess the quality of supply of electricity.
[2] Interruptions from 100 milliseconds up to three minutes.
[3] EIFS 2010:5 Section 21, the reported data shall be of good quality. The DSO shall design their systems and procedures in such a way that the data, aggregated to the average values for the 100 delivery points and border points, do not differ by more than three percent of the actual value.
[4] IEEE Guide for Electric Power Distribution Reliability Indices, IEEE Std. 1366-2012.