INTEGRATING DISTRIBUTION MANAGEMENT AND THE CORPORATE REQUIREMENT FOR INFORMATION

Derek MACFARLANE
GE Energy - UK
Derek.macfarlane@ps.ge.com

The competitive environment and the Regulatory environment surrounding Distribution management cause a high level need of information that used to be solely of interest to control centre operations managers and technical staff.

Acquiring that information and using it for public and regulatory reports also introduces a requirement for an audit trail to assess the accuracy of the information. This paper discusses the acquisition of data from all aspects of the operations environment and its conversion into reports supported by audit trail and the attainment and maintenance of high levels of data accuracy.

The UK regulator, Ofgem, has placed a requirement for data accuracy and auditability on the UK Distribution Network Operators (DNO). The regulator has viewed this as an essential first step towards inter-DNO comparison and the assessment of network performance targets within a penalties/rewards programme designed to incentivise medium/long term investment in infrastructure.

INTRODUCTION

Traditionally, the Distribution network performance metrics have been guessed.

Each fault report required an estimate of numbers of customers per affected feeder and numbers of customers restored per stage of restoration. Although customer connectivity data may be held at high levels of accuracy in geo-spatial systems, many geospatial systems do not update the data in timeframes suitable for use by real-time and near-real time systems and the use of this data integrated into dynamically changing network connectivity has only become available in the last 9 years. Many companies still do not have this integration – so engineers estimated the answers needed for fault reporting. One method of estimation was to obtain the SCADA reading for an MV feeder, or the maximum demand reading for a transformer and allow an after diversity maximum demand figure of 1.5kVA per domestic premise and divide the SCADA reading (converted to kVA) by the ADMD to obtain a number of customers affected.

Variations on this theme abound – but essentially the network performance data is guessed. A definition of near real time as it is applied in this paper is as follows:

The MV requirement for “near real time” is a manual update operation made within 5 minutes of the event, and the manually entered time of the event should be as correct as possible – to a one minute accuracy. Actual date time stamps should be used where they are available e.g. from SCADA and customer call logging.

IMPACT ON REPORTING ACCURACY

Fig 1. Pie chart displays the contributions made to Customer Minutes Lost per connected customer (CML).

MV faults contribute 70% of CML and MV planned outages contribute 2%

LV faults and planned outages contribute 14% of CML. An error of, say, 10% in MV system CML data contributes an 8.4% error to the overall total

Therefore it is 5 times more important to get HV customer connectivity correct rather than LV. For a given reporting accuracy, the business case is made for the HV network data to be highly accurate – run from a dynamic HV network model because it is crucial to accurate reporting.

A solution of less accuracy is sufficient for reporting LV network CML. eg connectivity based on a static LV system model will still enable the overall reporting accuracy to be achieved. Due to the lesser importance of the LV data, this needs to be collected and maintained for a minimum cost per item of data. A simple organization of the transformer data into lists per LV feeder suffices to provide sufficiently accurate data to enable reporting within the 95% overall accuracy and 90% LV reporting accuracy.

Please note there may be other business imperatives that require a higher accuracy of LV connectivity data, but reporting is not one of them.
SOURCES OF ERROR

Lack of System Integration.

The major source of error is caused by the use of disparate systems, a stand-alone SCADA system, an alternative method of logging manual switching from crews, and an outage management system accessing customer calls.

As Fig. 2 indicates every system has its own version of “the truth” within the limits of the data collection for each system. However, the issue of overlaps and gaps between the systems means that there is no simple correlation between the total number of incidents in each, they cannot be simply summated.

This difficulty prevents the data being of use in near real time, because historical analysis is needed to identify the overlap and gap issues. This in turn leaves managers operating from guesswork and estimates, and this affects the strategic decisions they make or indeed do not make. Even when interfaced together these differences remain.

Errors unless abnormalities are identified.

Updating manual MV switching

Late or lack of updating of manual switching on the HV network can be almost eliminated by business process control measures – obliging switching to be reported timeously and also by empowering site crews to log confirmation of their switching electronically on to remote intelligent devices such as laptops, notebooks PDA’s that are in communication with the control room DMS.

Lack of updating any switching on the LV network

This means that customer connectivity data can be temporarily incorrect, and a potential source of eroding data accuracy over time is introduced if the business processes to track “system normal” are not rigorously implemented allowing some temporary change to become permanent.

Customer connectivity data granularity.

LV reporting accuracy depends on data granularity. LV outages affect only one feeder emanating from the MV/LV transformer. The fault may only affect one or two phases of the feeder, or only a section of the LV feeder. The data granularity should ideally support per feeder, per feeder section and per phase. This applies to the organisation of connectivity data for every MV/LV transformer.

The cost of data collection and the cost of data maintenance are the main factors in driving data granularity over the long term. There is a cost / data accuracy balance – a Pareto effect where the last 20% of data accuracy costs 80% of the data maintenance effort.

The maintenance issues are potentially larger than the data collection exercise:

1. Continuing that level of data maintenance within a near real-time updating target.
2. Maintaining a control over LV system work and switching sufficient to support item 1.
3. Updating the addition or removal of secondary transformers within MV standards of near real time – and particularly for removal – it must include an insistence of reconnecting the customer connections to alternate sources modelling exactly what happens in the field – either prior to transformer de-energisation or during the reconnection to a new or alternate transformer.

This data maintenance workload implies a fairly large team – the LV network has approximately 10 times the number of
components and 10 times the amount of site crews applied to it compared to the MV network. Reference can be made to the MV control room staffing and database updating staff and estimate how many extra staff will be needed to add LV near real time control and LV data update in near real time. In recognition of this potential increase in operating costs, a more pragmatic approach has been taken by the UK Regulator in setting a 95% data accuracy limit with a 90% data accuracy on LV reporting. This pragmatism recognizes the need to constrain costs passed on to customers, and avoids the need for dynamic control of LV networks.

Static or dynamic network connectivity

The use of a “static” or “dynamic” network connectivity diagram at MV level does affect reporting accuracy because of the larger numbers of customers per incident.

By reporting from a dynamically updated MV schematic on which SCADA and manual switching, and customer call logging, are recorded in at least near real time, and the customer connectivity algorithm accesses the network live/dead status of the transformers on that dynamic network, then the errors relating to a static model can be avoided. MV reporting on dynamic networks is therefore by default almost 100% accurate leaving only the update latency as a possible source of error. A static MV model, organizes customer connectivity data from source to normally open point, and requires manual reporting adjustments and explanation of abnormalities.

SOLUTIONS

Currently, some utilities have invested in creating a connectivity database in GIS, others have created lists of customers per transformer on static primary transformer, MV feeder, and secondary transformer referencing number schemes, some have listed customers per transformer on their dynamic operational schematic diagram, and some still guess. While all these solutions still involve an element of error, only some have a serious effect on accuracy and auditability.

Given the comments relating to sources of errors and the relative importance of accuracy on HV versus LV systems the solutions can be categorized into:

- Static versus Dynamic diagrams
- MV and LV networks
- Granularity of Customer connectivity
- Multiple Databases versus an Integrated Database

The solutions are tabulated as shown in Fig 3 below.

TABLE 1 - Relative Impact of Functional Solutions on Reporting Accuracy and Auditability.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Accuracy</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static MV network</td>
<td>Too</td>
<td>Inaccuracy amplified by the high impact of the HV network on total network performance measures. Audit will highlight inaccuracies.</td>
</tr>
<tr>
<td>Static LV Network</td>
<td>Acceptable Accuracy</td>
<td>Error rate acceptably low due to low overall impact on CML and data consistency from the use of an integrated database. Audit may object if there is poor tracking of changes and edits.</td>
</tr>
<tr>
<td>Dynamic MV Network</td>
<td>Acceptable Accuracy</td>
<td>Provided business processes are in place to record manual switching and customer no supply calls in near real time. Straightforward audit trail back to date time stamps of switching items.</td>
</tr>
<tr>
<td>Dynamic LV Network</td>
<td>Overkill</td>
<td>Too expensive to collect and maintain compared to its impact on reporting accuracy – unless there are other business requirements that can enhance the case for it. There are so many connectivity changes at LV that auditing a dynamic network state will be difficult.</td>
</tr>
<tr>
<td>Done nothing new and continue to guess</td>
<td>Too</td>
<td>Inaccurate Fails to meet the changing business requirements and is not auditable.</td>
</tr>
<tr>
<td>Connectivity per premise (GIS)</td>
<td>Acceptable Accuracy</td>
<td>More expensive data to collect and maintain than other systems, but its accuracy is the best. provided it has tight business process controlling a short latency of update. Audit will focus on updating issues.. Expense is not justified at current accuracy requirements however if the business believe the Regulator will press for even more accuracy this is the solution.</td>
</tr>
<tr>
<td>Connectivity per LV feeder per transformer</td>
<td>Acceptable Accuracy</td>
<td>Substantially less expensive data to collect and maintain, sufficient for LV and MV reporting, and auditable providing tracking edit changes is done transparently. More difficult to justify in audit if the Regulator increases the accuracy requirements.</td>
</tr>
</tbody>
</table>
Summarising this table, a system with an integrated database across SCADA/NMS and OMS functions, which utilizes a dynamic data/network model at MV and at least a static data model at LV is sufficient to produce network performance data that is >90% for LV network reporting and >95% overall LV, MV and HV network reporting. Fig. 3 represents this solution.

The HV and MV networks, must be capable of real-time (SCADA) updates and near real time manual switching updates. The near real time manual switching is as much a business process requirement on crew and control room operator practices as it is a functional requirement of NMS and OMS. In addition OMS must provide near real time customer call data, so that the data synchronization across SCADA and manual switching and customer calls can all make sense. If customer calls are batched through, say, every 10 minutes, then the OMS will be inferring customers are off supply when in fact the supply was lost due to a SCADA trip and restored with an attempted SCADA re-closure after a few minutes.

The LV system functionality does require transformer level granularity of customer connectivity to be further organized into LV feeder lists, and GIS data and or previous historical incidents are useful sources of this data.

The LV system functionality associated with this data requires to recognize single LV feeder faults and provide a “divide by 3 option” to guess the impact of single phase LV faults. The OMS can verify part of this estimate by identifying actual callers who have been off supply.

The functionality also requires data tolerance features so that minor data inaccuracies do not cause the system to malfunction in a serious way for minor inaccuracies. The functions must enable data correction opportunities to allow for operator keying error and for the data error inaccuracy. Audit requirements focus on the opportunities for manual intervention in a system driven process. Therefore where draft report anomalies are found, data correction can be made possible but this must be an edit entry that is itself date time stamped, the edit must be undertaken by an identified operator and for a given reason enabling an auditor to make a judgement on its acceptability.

**SUMMARY**

Reporting accuracy and capability to be audited is greatly enhanced by integrated functions using the same database rather than interfacing disparate functions each with their own database.

The operational functions of SCADA, NMS and OMS must operate and be updated in real time and near-real time.

The customer connectivity data maintenance requires a disciplined business process controlling update latency. Minimal manual editing of reportable data should be the aim, and any editing undertaken must be visible to the auditor and complete with ID of editor and reason.

Finally, in achieving a system where reporting is sufficiently accurate to enable inter-company comparison with sufficient confidence to use it as the basis for allocating millions of Euros in penalties and rewards, the disciplines and products also enable near real time strategic
management of storm situations with increasing competence, faster response and consequently better restoration times.

However there is also a risk of sub-optimisation by devoting too much investment in controlling relatively unimportant LV customer connectivity data at a rate sufficient to drive accurate reporting. The impact of the LV network on overall network performance and on the relative accuracy of reporting does not merit the costs involved in data maintenance, and a pragmatic rather than idealist approach to LV customer connectivity enables an optimal reporting solution with fit for purpose accuracy in reporting and auditability.