APPROACH TO THE TECHNICAL LOSSES CALCULATION

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ABSTRACT

The technical losses calculation methods are common tools to optimise the design, planning and operation of the electrical networks. Recently, the technical losses are one of the facts with very high impact on the economical issues of the electrical energy rates for customers at distribution level, when these rates are fixed by a governmental agency. Usually a fixed technical losses percentage is assumed, and the utility must optimise the actual figure for not paying an over cost even without consider the pure technical issue. Edenor S.A. has worked in the technical losses calculation in a team with other companies of the EDF group (EDF France, EDF energy, EnBW, Demasz, Light, Edemsa) that collected the best practices from them. Finally, (and with the experience from the work mentioned above), Edenor S.A. is developing an approach in order to improve the technical losses calculation at the different voltage levels. In addition, how to take advantage of the data from some information systems that are mandatory due to the control activity imposed by the Concession Contract, e.g. the link between customer and network in order to track the interruptions record of each customer.

INTRODUCTION

The technical and non-technical losses are one of the facts with high impact on the economical issues of a distribution utility.

With reference to the non-technical losses, that are a nightmare in certain areas of some countries, many papers had been written, usually to resume the actions to reduce these kinds of losses, but it is necessary also to identify the technical losses in order to deduce the term of the well-known equation:

Non-Technical Losses = Energy to the network – energy in meters* – Technical Losses.

*Energy in customer's meters (function of the billed energy).

Therefore, there are many incentives to an improvement of the calculation methods for the technical losses:

the classical optimisation of the networks as stated above, the rate component when a governmental agency fixes the kWh price, and the knowledge of the non-technical losses.

COMPANY AND SYSTEMS DESCRIPTION

Company Description

Edenor S.A. is an argentine electric distribution company that covers an area of 4 637 km², with around 8 000 000 of inhabitants, (north of the Buenos Aires city and the northwest of the Great Buenos Aires), with approximately 2 435 000 customers, a billed annual energy of 16 625 GWh with a maximum demand of 3 450 MW. There are 63 HV/HV and HV/MV substations, 14 000 MV/LV substations with around 4 780 installed MVA, and a network length (kilometres) of approximately 1 280 kms HV, 8 700 kms MV and 24 000 kms LV. Their concession area includes zones of very high load density in the city of Buenos Aires, suburban areas and countryside & rural zones of low density too.

Systems and Data Availability

SCADA and DMS Systems. All the Edenor substations HV/HV and HV/MV are integrated in a SCADA/DMS system for about ten years (right now the systems are been updated and integrated to fulfil the IEC protocols).

The availability of a SCADA in this level (HV/MV substations) is mandatory to apply the calculation method or at least a continuous record of the load profile of each MV feeder.

Technical Information System. Edenor S.A. has taken the data availability that comes from his own technical service information system (supply continuity), that is mandatory due to the governmental regulations, In brief, the quality regulations ask for a complete record of all interruptions of each customer (HV, MV or LV level). Then, if the fixed quality standard for the customer is not fulfilled, a penalty is applied as a function of the non-supplied energy, calculated by an algorithm. This fine is applied as a credit in the customer's energy bill.

To keep and track the interruption's record of each customer is obligatory to know and actualise the link between the client and the network, in order to apply an automatic fines calculation method, due to the task complexity and the data volume.

This information system has been operated for ten years, and now is being updated to use the GIS tools.

The essential fact here is to know the link between customer and network (and to maintain this link updated).

Of course, all the commercial data are also available through the customer's account.

For Edenor S.A., all these data are without additional cost for use in others systems, like the technical losses calculation.

Other data. The load profile of each type of customer is also necessary. To the date, the standard load profiles of the Concession Contract are used. A survey to update this data is carrying out at this moment.

PREVIOUS LOSSES CALCULATION METHOD

Edenor's methodology

When Edenor S.A. takes the operation under the rules of the Concession Contract on September 1st, 1992, the main problem to solve in order "to keep alive" the company was to reduce the losses level (nearly 30 % or more in some areas).
Of course, the actions were focused on the non-technical losses (theft, fraud, etc.), and a simple method to calculate the technical losses was put in service in order to control the losses evolution:

The Technical Losses as a whole at the level of HV lines and HV/MV Substations were calculated by the simple formula:

$$\Sigma \text{ Energy in boundary} - \Sigma \text{ Energy in MV busbars}$$

The energy meters at the boundary with the National Grid and/or other companies and in the MV busbars of the HV/MV substations supplied the data, usually in a monthly basis.

At the MV level, the Edenor's method made an estimation of the technical losses in the MV network using an approximate model that calculate the losses in average MV feeders representatives of the whole network in each Zone (Internal Administrative Division). The relationship between utilisation time, equivalent time of losses, power factor, simultaneity factor between MV feeders, etc. (at HV/MV substation level), were introduced in the calculation formulas. The network circuits were modelled in each internal administrative division taking in account the MV feeder type (Overhead, underground or mixed type). For the MV/LV transformers the usual calculation method (Iron & cooper losses) was used with a typical classification according to the Zone type.

At the LV level, and with basis on the load relationship of each MV/LV Substation type, and the number of typical LV feeders by each value of transformer standard power, the current by LV feeder has been calculated. The losses in the 3x380/220 Volts underground and OVH networks were evaluated separately.

Different typical LV networks in each area have been defined and for each one of them, the losses corresponding to a characteristic sector (assumed as symmetrical) were calculated. First, it was assumed that the load is uniformly distributed between the phases and the LV feeders of the MV/LV Substation. Then, some correction factors were applied (the non-uniformity in the currents of each LV feeder, branches component, asymmetry and imbalance of phase currents, etc.)

The losses in connections and meters were considered too.

In addition, and to complete the equation in the introduction, the energy in meters must be calculated:

The energy sale of a determinate month 'X' is given by the equation:

$$\text{Sale}_X = \text{Invoicing}_X + \text{Energy in the meter}_X - \text{Energy in the meter}_{X-1}$$

The energy in the meter is an estimation of the consummation registered on each meter between the last date of control and the end of the month. This estimation is linear with the number of days in each billing and the load profile for the whole of the company.

In brief, this method gives the evolution (on an annual mobile basis) of the non-technical losses in each administrative division, and the errors derivates from the method were accepted, because the main purpose was to know and control the non-technical losses.

Is a method based in the calculation for typical network units and extrapolated to the whole network of each administrative division.

Many others utilities employed this approach (or some variation) up until now.

NEW APPROACH

The description of the precedent methodology finish with a very simple conclusion: Nowadays, the IT state-of-art, and the availability of data that comes from other systems, facilitates enormously the introduction of a new methodology to improve the calculation of the technical losses.

A brief description of the Edenor's approach is given now, for each voltage level.

HV Network

The method of evaluate the technical losses as a simple comparison of the energy meters, has the constraint that the percentage of technical losses is in the order (or nearly) of the meter's error.

Therefore, the well know methodology of load flow can be employed. A company named SACME manages the local HV network in the Buenos Aires City and surroundings that connected the national grid (500 kV) and the HV/HV and HV/MV substations. This company is owned by Edenor and the other utility (named Edesur), that serves the Buenos Aires area to the south, with approximately 2 200 000 customers and an area of 3 309 km²).

The load flow and losses calculation are performed regularly by SACME, then the data are available at no extra cost for Edenor, which is mainly a distribution utility as stated above.

The load flow has proved to be a much better method to obtain the losses in this level, and in the end, the data from the meters are available to verify the calculations.

MV & LV Network

Here, the method uses a similar approach, due to the data accessibility:

The complete distribution networks, including the HV/MV substation to the LV customer meter with his topological connection and electrical parameters are available (and the process to convert these data to GIS architecture is nearly completed).

Of course, the model can be improved with the practice, once the basic information are available, e.g. add the losses in fuses. Nowadays the IT offers a power calculation not imaginable few years ago, and the problem is not to process the data but to get them.

The information system (to track the interruptions record of each customer, as stated by the Concession Contract), has been improved, and now a time stamp will be added to allows to know the change of state (open/close) of every switch in every voltage level. This way, it is possible to reconstruct the network state in a time axis.

With all this data, it is possible to calculate the technical losses for each unit of the distribution network (including the chronological changes in the topology).

MV feeder: For a given period (e.g. a month), all the data will be available:

The changes in the feeder topology due to a fault, a maintenance work, etc., can be tracked to the minute and then the technical losses calculated with the exact topology at each time, for the given period (usually the calendar month).

There are many dedicated software in the market that can be integrated with the data that derivate from the information system.

Nevertheless, it is necessary to know other type of data: the load profile on the network.

There are two types of data, those that can be easily measured and recorder (e.g. from the SCADA at the head of each MV feeder), and those as the load profile in each MV/LV substation in the MV feeder that must be evaluated from other source.

Nowadays the price of a solid state recorder with the appropriate sensors and memory capable to keep the load profile data at the MV/LV transformer is about 500 u$s in the local market (Argentina). Compared with the total cost of the MV/LV substation it is possible to install this kind of equipment, but this approach not solve the problem of the load profile in the LV network, and the cost of maintenance and data recuperation must be added too.

Here appears the advantage of the knowledge of the link of each customer to the network.

If the load profile of each customer (based in the available data: billed energy, tariff, voltage level, type of use) can be known, then it is possible to add the load profiles of the customers linked to each MV/LV transformer of the MV feeder. With these data, the typical load flow can be run, and the technical losses calculated.

However, the use of solid-state recorders in some points can be useful to validate the data indirectly obtained.

When the registered energy at the head of the MV feeder, the calculated technical losses, and the billed energy for a given feeder does not match, a non-technical losses problem can be the answer, and then a more fine analysis must be carried out.

LV feeder: The same way of the MV feeder can be applied. The network electrical parameters, configuration along the given period and load profile at each point are known.

In the utilities that use the U.S. network style (many low power transformers and few customers in each MV/LV transformer), the calculation in the LV level can be simplified a lot. It is not the Edenor case with a media of

370 kVA and nealy 200 customers per transformer)

Load Profile Survey

As stated, the customer's load profile is necessary to perform the calculation. The Concession Contract fixes the load profile of each type of customer in order to calculate the non supplied energy in interruptions and also to evaluate the contribution of each customer category to the whole demand (a information necessary to fix the rates for energy and power demand).

These load profiles has been used to the present, but they are more than ten years old, and a mandatory survey is carried out now to update the data (These data will be used in the new Concession Contract also). It is to note that the use of air cooling devices in the residential segment has grown-up exponentially in the Buenos Aires area, so the load profiles are changed sharply in relationship with the temperature.

The survey has been prepared with the hypothesis of an error of 5 % with a 95 % statistical trustworthiness.

Statistical techniques have been employed to choose the adequate sample size. To record the data in each customer chosen as sample, a solid-state billing meter with recording capacity has been used.

The samples are (with demand limits):

371 residential (< 10 kW)
351 general use (like small shops) (< 10 kW)
307 medium consumption (> 10 kW and < 50 kW)
440 customers > 50 kW
50 big customers that buy the energy in the market and pay a toll to Edenor for the network use.

This survey is complemented with a "network survey" with solid-state recorders installed in some MV/LV transformers.

Also, many customers in the range of more than 50 kW have an energy meter that records the load profile with an integration time of 15 minutes for billing purposes. In some cases, the "sliding window" technique can be used, so the maximum demand can be determined in a 15 minutes period not binding to the exact hour (e.g. 10:13 to 10:28 and not 10:00 to10:15, or 10:15 to 10:30). This is valuable information that can be obtained at no extra cost, and employed beyond the aim of the survey.

CONCLUSIONS

The technical losses knowledge has capital significance for the distribution utilities because:

a) They are necessary to optimise the design, planning and operation of the electrical networks, as a well-known engineering standard procedure, utilised for years.

b) They are a term in the equation to evaluate the non-technical losses (a very important fact in many utilities because the problem of theft and fraud).

c) When the rates are fixed by a governmental agency, (as the case of many distribution utilities originated in the privatisation of public companies) the figure is usually a term in the equation used to evaluate the utility recognised cost. This way, is nearly mandatory to maintain the loss figure as low as possible, because the non-technical losses economical value is not accepted in the fixed rate.

The state-of-art and IT technologies permits nowadays the availability of information nearly for free, which can be used to improve the old methodology in the distribution level (calculate the losses for a standard network and then extrapolate to the whole).

It is possible right now to calculate the technical losses for each voltage level of the distribution network, even for each LV feeder if desired. The old extrapolation method can be used partially in the areas where the new technologies are not implemented yet.

Once the information system (mandatory in many cases) is operating, the technical losses procedure and calculation can be established as a standard, because nearly all the data can be obtained automatically.

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