LOSSES ASSESSMENT AND PREDICTION IN HV NETWORK USING DATA ACQUIRED WITH AMR SYSTEM

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ABSTRACT

Recent developments of liberalized energy market promoted Automat Meter Reading systems as the principal instrument for metering operators. Over the past years few years information gathered from field energy meters accumulated in very large databases.

This data can be used for different purposes beside that of just determine energy quantities like, for example, a better method for losses assessment.

Technical losses in 110kV distribution network are determined today using computer applications based on equivalent time method.

Because technical and measured losses in 110kV network at SDEE Sibiu exceed the accepted national average, we had to conduct a more detailed analyse to determine the actual causes of this situation. A spreadsheet application was developed for this purpose. This application uses information acquired by AMR (Automatic Meter Reading) and load curve integration method.

This paper presents losses analyse performed with this application for all 110kV network elements during a four years study period, from 2006 to 2009. Graphical representation of both load curve and losses evolution over time is possible because losses are calculated for each hour. That means a proper correlation can be observed between losses amount and network topology. More important this method creates a consistent database for losses prediction algorithm validation and implementation in future expert systems.
Taking into account the necessity for losses prediction in present energy market conditions and based on obtained results, some proposals for losses calculation optimisation are presented.
Because power losses assessment and prediction can be considered a DMS function we share our considerations about AMR place into future integrated systems and the advance toward Intelligent Distribution Network.

Key words: AMR System, losses.

INTRODUCTION

Network losses represent a major cost in the delivery of electrical energy. A clear and accurate policy on loss evaluation and costing is required to ensure that limited capital resources are used to best advantage across the total power system.
Distribution loss reduction is in many cases cheaper than committing generation plant and fuel to supplying losses over the life of a network. Distribution loss reduction requires a wide range of measures.
Need for detailed analysis of losses in 110 kV network was determined taking into account the general conclusions of a study on energy losses performed in year 2005 by ISPE, the most important design institute in Romania in energy domain. Some conclusions were further detailed for Sibiu Distribution Subsidiary:
There was a need for careful energy determination in the 110kV network and take measures to increase measurement accuracy especially in those areas where losses overruns the maximum value by more than 10%.
Until 2005 losses in distribution network were determined at the end of the year using equivalent time method. This method was perfected during last decades and can give accurate results over a definite period of time. The main disadvantage is that the evaluation is done over the entire interval and the results accuracy improves with the interval length.
For some 110kV Over Head Lines, Sibiu Distribution Subsidiary has reported values well above the maximum allowable loss, even if in this case losses are not affected by corona and commercial loss. Those cases require a detailed analysis (based on P, Q, U readings) in order to optimise operating procedures.
To assess the effects of normal operating schedule changes due to activities Transelectrica SA tracking the energy flow in exchange points (including Transmission) was also important.
Study results for last 5 years showed that 25% of total energy loss in distribution network is located in HW network. It also highlighted that these losses are located mainly in 110kV OHL which holds 81% vs. 19% located in 110/20kV Transformers.
The considerations above determined us to develop an application for losses calculation for each 110kV OHL and 110kV substation transformer using load profile integration method. This method is used to calculate values for absolute and percentage loss on user-determined intervals.
The results obtained led to the idea to use this method to develop a report inside AMR (Automat Meter Reading) system used in Sibiu Distribution Subsidiary for direct determination of energy losses.

AUTOMATIC METER READING SYSTEMS

Automatic Meter Reading (AMR) Systems are widely used today to acquire information from remote energy meters installed in common coupling points. This information is stored in relational databases, processed and used to establish energy exchanges on the market.

Present day electronic meters can be considered Intelligent Electronic Devices (IED) since they perform acquisition and measurements of electric quantities in network nodes and store them in internal memory. Usually the measurements are accessed from a remote control centre using digital communications and downloaded according a predefined schedule. In figure 1 is presented the information flow from field meters to final users. The architecture of AMR systems resembles one of a SCADA system. The main difference is that SCADA systems performs ON-LINE data acquisition and bi-directional communications instead of data download on request as in the case for AMR systems. Still we can recognize the communication infrastructure, the central database stored on a powerful server and the computer network used to provide users with different reports according access rights.

Measurements presented in this paper were obtained using the AMR system developed in recent years in a Romanian distribution branch. This system manages electronic meters installed in:

- 110/20kV distribution substations for each overhead 110kV line and on each power transformer high and medium voltage side.
- common coupling points with other partners such as transmission operator and hydro power plants.
- Energy measurement installations for eligible customers.

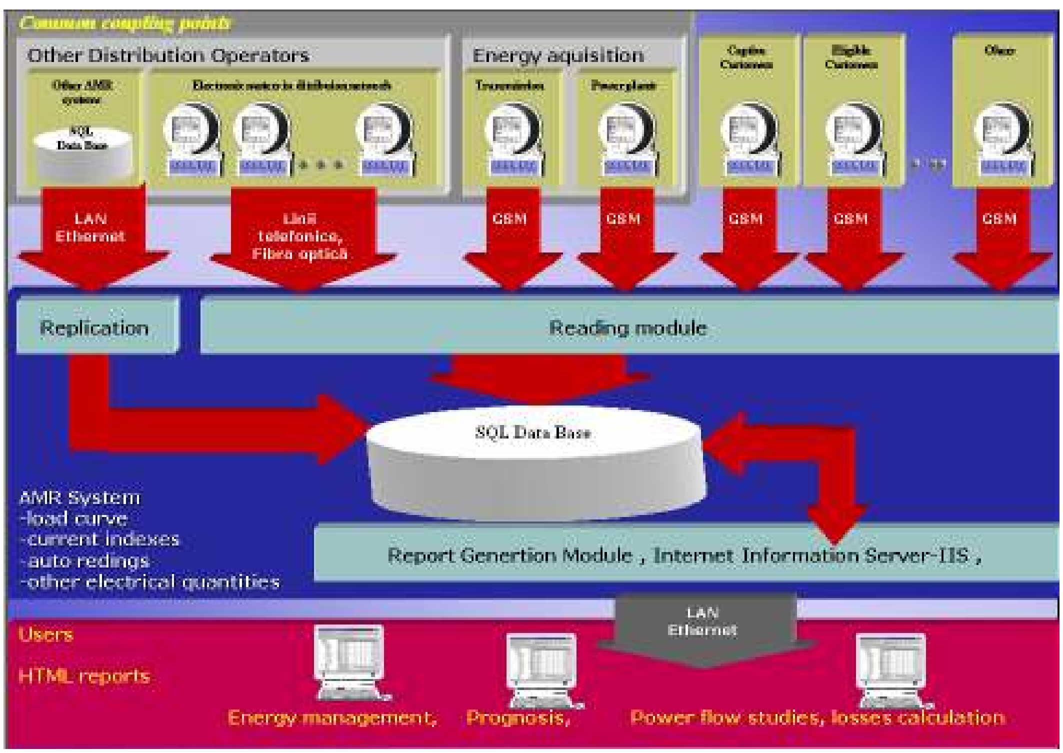

Figure 1 Information flow for AMR system

Equipments used to develop present AMR system are electronic meters, communication equipments (analogy and GSM modems, multiplexing units and a wide range of converters and servers, computers and other peripherals at central headquarters

In order to be integrated in the AMR system the electronic meters need to be able to measure the active received and delivered as well as the reactive energy in the 4 quadrants highlighting the inductive and the capacitive components. Those meters are storing the information regarding the electrical power received and delivered using 4 channels for the load curve. The period when the load curve is stored depends on the size of the storing interval and on the number of channels used.

LOSSES DETERMINATION IN HV NETWORKS

Energy losses are intrinsic to the process of power delivery. Some of the energy flowing trough the electricity networks is dissipated as heat in the conductors and transformers in the system. Such loss of energy clearly needs to be controlled ad minimised as far as possible. These energy losses cannot be eliminated in any economical or practical way and are usually referred as technical loses. What we need to do is to control or reduce them to a least damaging or economically optimal level.

For HV networks commercial losses determined by unmeasured energy and low accuracy measurements are virtually nonexistent so we can consider that in this type of networks only technical losses are occurring.

In order to minimise losses first we have to know their amount. Because in HV networks percentage losses in network elements are usually around 1%, direct measurement is very difficult since combined accuracy of measurement chain is of same magnitude.

The only way to asses losses values is by calculate them using network parameters and measured values for distributed energy. In time, various methods were developed for that purpose.

In Romania the “”Equivalent Losses Time” method is well established for losses determination. The equivalent losses time is the calculated period that produce in a network element working at peak load the same losses amount as in the whole operation time during normal load condition.

Values for equivalent time are obtained with different formulas using load profile parameters as variables.

The main disadvantage of the method is that it’s accuracy is increasing with the length of measured interval. Usually losses determination was performed over three months evaluation period or even for one year interval.

Need for shorter evaluation period led us to the idea of using data acquired daily with AMR system to calculate losses for each hour and for each network element. So instead of evaluating the load profile parameters and equivalent losses time, we calculate the energy losses each end every hour considering the medium value of active and reactive power over one hour equal to the value of corresponding active and reactive energy recorded in that hour.

In case of Over Head Lines the formula used for active energy losses calculation is:

$$\Delta W_h = 3 \cdot R \cdot \left| \frac{\underline{S_h}}{\underline{U}} \right|^2 \cdot 10^3 \qquad (1)$$

In case of HV/MV transformers the formula used for active energy losses calculation is:

$$\Delta W_h = \left(\left| \frac{S_h}{S_n} \right|^2 \cdot \Delta P_{Cu} + \Delta P_{Fe} \right) 10^3 \tag{2}$$

Losses over the entire evaluation period is then calculated as sum of the hourly values:

$$\Delta W_{tot} = \sum_{h=1}^{n} W_h \tag{3}$$

where n is the number of hours in operation.
This method was applied for each HV network element using load profile recorded for one year interval. The results were then compared with that obtained with equivalent time method. The main conclusion was that for different power lines we should use different formulas for equivalent losses time in order to obtain accurate results. This means that only one formula for losses calculation was not sufficient. Still the aggregate values for all network elements, obtained with both methods, were close enough.
Figure 2 shows the condensed results for all OHL included in the study for year 2009. Values are represented in MWh and % for each line. As it can be see the values differs very much from one OHL to another depending on electrical parameters and condition of operation (closed loop or radial).

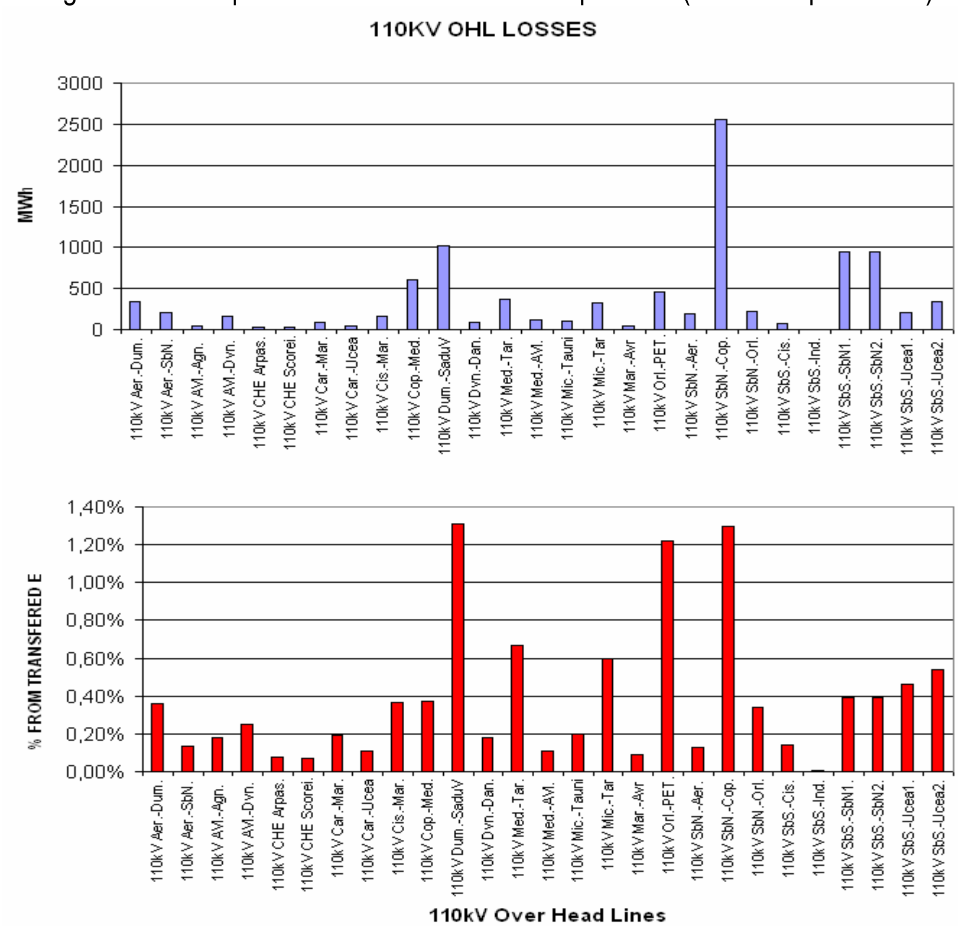

Figure 2 Losses in 110kV OH Lines in year 2009

Because losses are calculated each hour we can represent them over the time line. For this purpose a graphical interface was developed. It can be observed in figure 3 and contains following areas:
-Selection of the time interval (month) to be represented in the graphic above
-Selection of the magnifier interval to be represented in the graphic below
-Results section where loses calculated in MWh an in % from transferred energy are displayed.

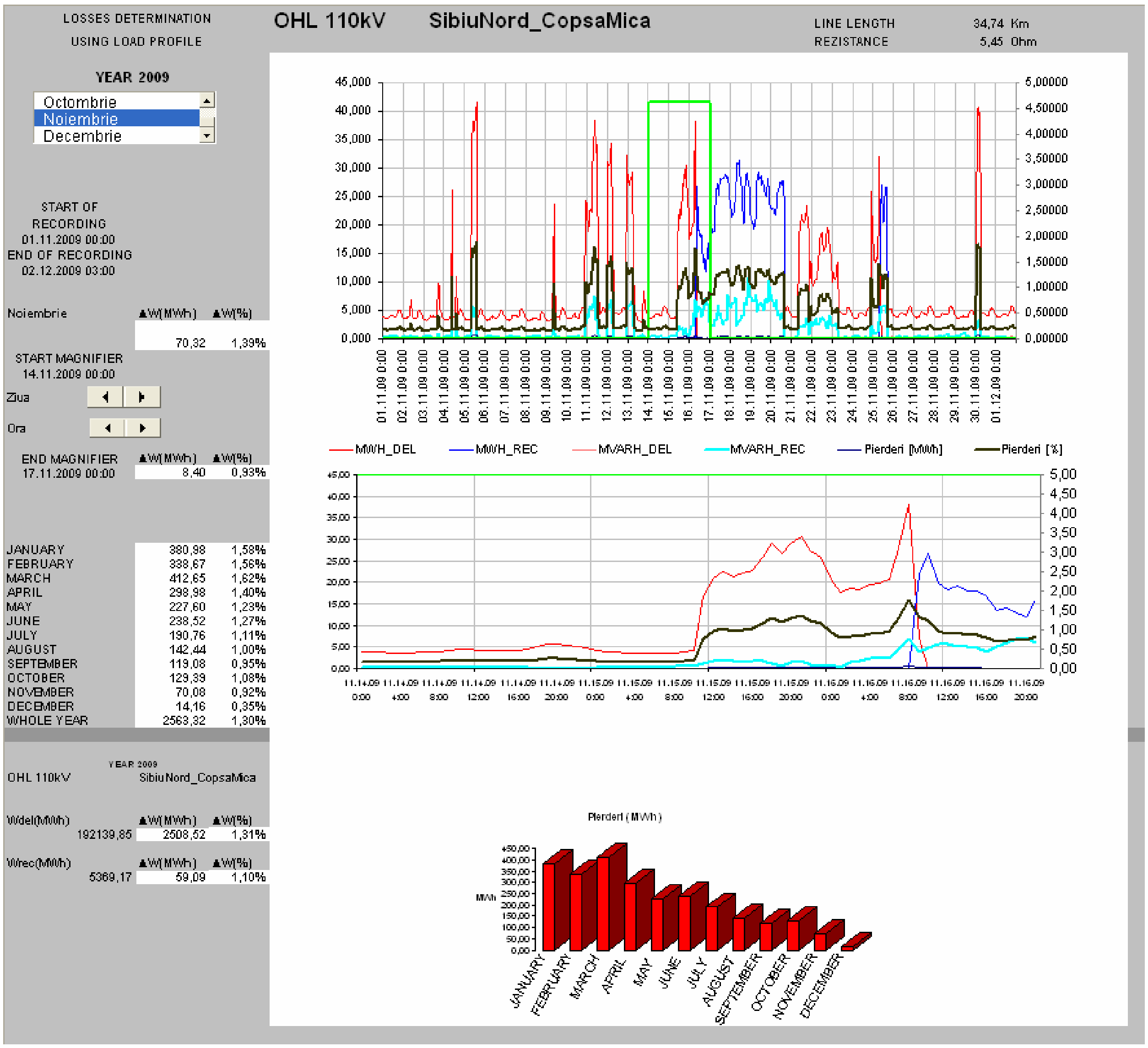

Figure 3 Graphical representation of losses over time

Figure 3 shows load profile for OHL 110kV Copsa-Sibiu Nord in November 2009. This line contribute with the highest value for losses because is part of a loop designed to be reserve for transmission network. With dark line percentage losses are represented. As it can be observed on secondary axis the value jump from 0,2% in open loop operation mode to over 1,5% in meshed operation. Year percentage value for this line, at 1,3%, is three times higher than average for OHL at 0,4%.
When aggregate losses are calculated from summation of individual losses profiles(Figure 4) some interesting conclusions can be derived: only four OH lines contribute to most of technical losses in surveyed

network. Energy produced in Sadu V hydroelectric power plant is distributed via 110kV OH Lines –SaduV-Dumbrava-Aeroport-Sibiu Nord-Copsa Mica to a metal processing plant. It's no surprise that losses on this axis are almost 80% from total.

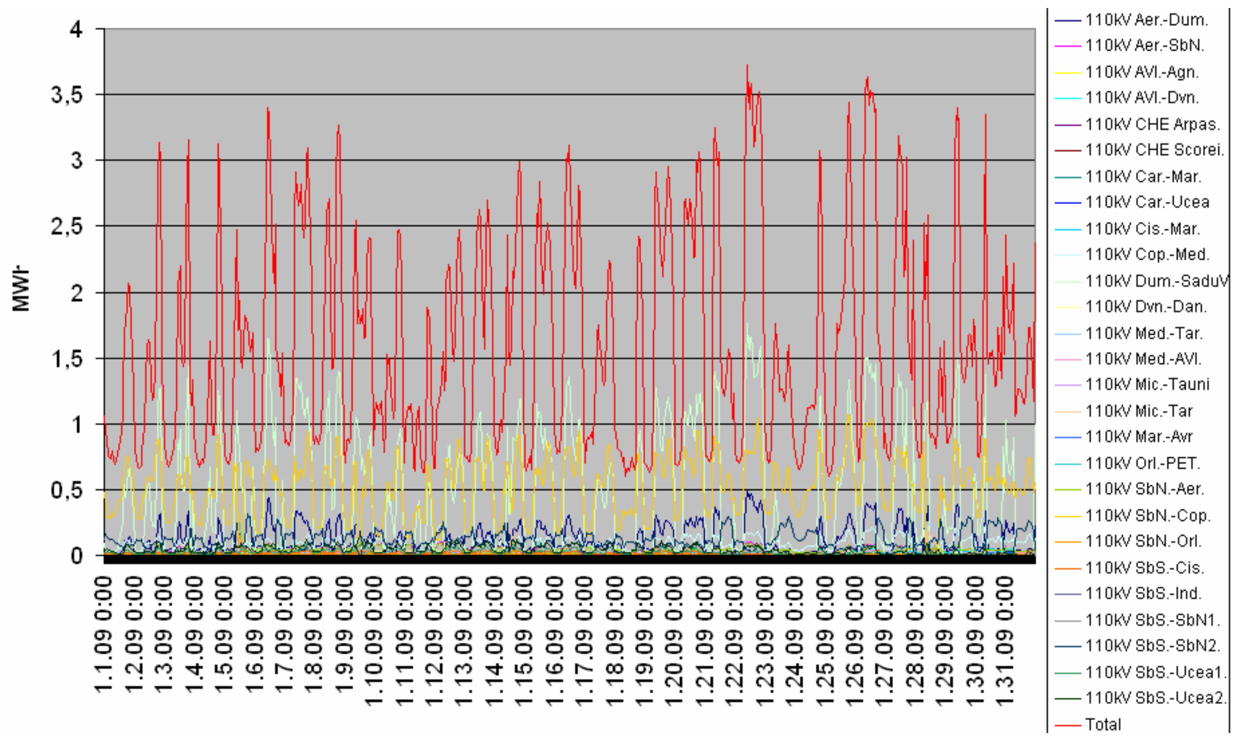

Figure 4 Aggregate losses in OH lines in January 2009

Same method was used to determine losses in HV/MV transformers. In transformer's case the obtained values match more close that provided by other methods, because independent losses are predominant.
The method described above was used for last 5 years and helped us to identify the most unfavourable operating conditions. Planning of maintenance is now conceived in order to avoid those conditions.
The method is implemented in AMR customized reports that can be accessed from intranet enterprise network.
During 2010 a major extension of AMR system is expected and the method will be applied also for MV network feeders.
This project will be completed with a nation wide plan to measure delivered energy from all MV/LV transformers in the network with a centralized system.

CONCLUSION

Previous method for loss determination in HV networks were used over quarterly intervals. The proposed method allows calculation of monthly losses by aggregation of losses calculated each hour. In special cases the analysis can be conducted for intervals specified by the user. This can provide a more detailed type of analysis.

Since the load profile is available for whole year, monthly monitoring is possible. The amount of losses in relation to the network operating mode ca be observed. By creating a window of detail user can focus area of interest for determining adverse situations.
This procedure revealed the causes leading to high losses of energy in 110kV networks, values that exceed the maximum accepted nationwide. The findings confirms the conclusion that the high level of losses is mainly due to the operating mode of 110kV distribution network which is not optimised.
Working on the analyse highlighted the importance of linking with other computer subsystems. Those can provide the technical data regarding distribution networks, with particular emphasis on determining the length of power lines using GIS.

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