THE CHALLENGE OF ADAPTING YOUR AMI-SYSTEM FOR LV-GRID MONITORING

Lars GARPETUN
Vattenfall Eldistribution AB – Sweden
lars.garpetun@vattenfall.com

ABSTRACT

Vattenfall Eldistribution AB has deployed smart meters for all customers and has long experiences of AMR metering for billing purposes and PLC based AMI systems. The aim is now to establish a low voltage grid monitoring solution based on the smart metering infrastructure. This paper will explain the advantages and challenges with adapting a PLC based AMI system to be used for low voltage grid monitoring.

There is a large advantage to use PLC communication with smart meters due to the physical interaction with the actual power grid. It is then possible to correlate meters to the grid using the PLC systems signal to noise ratio detection. So the AMI system will understand where in the grid a meter is placed even if the documentation of the grid in the Network Information System (NIS) is not correct. In this case the meter event information will be misleading for the operator, the meter events and the operators view in the DMS / LV Monitoring system will not match. Vattenfall are now developing tools for LV Grid mapping together with the AMI vendors.

Based on this Vattenfall will also develop functions for automatically identifying Power Outages, Power Quality and Power monitoring. This will be done based on filtering functions and algorithms in the AMI Head-end system. Data will continuously be validated and filtered and only trustworthy events will be forwarded to back-end systems such as DMS and MDMS.

A challenge for AMI systems based on the PLC technology is to handle high frequent noise on the grid and switched of meters (by the customers). This has a negative effect on the reliability, performance and response-times for the AMI system. There are possibilities to tuning the system and make it faster and with smart algorithms make it more reliable. The possible response-time for incoming events will probably be 5 to 10 minutes.

Using the AMI-infrastructure will be a cheap tool to establish low voltage grid monitoring and give DSO´s possibility to deliver customers better service and improve the processes. This will reduce costs for customer service, field crew activities and make customers more satisfied with the service.

BACKGROUND

Vattenfall has since 2003 built up an AMI-infrastructure based on PLC communication including remote controlled smart meters. The main reason for installing the meters was to improve the meter to bill process; streamline the work and to support the customers with bills based on actual consumption. Based on this, Vattenfall has taken the next step by using the smart meters in new areas.

The AMI infrastructure were originally designed to measure and collect meter values (meter stands and time series), the meter was named "AMR meter". Later on the AMR meter was developed in a direction to be smarter using basic voltage and current values in new ways, the smart meter was born. By combining voltage- and current levels, load flow directions and timestamps it was possible to create meter events showing the physical status at the place of the meter in the grid at customers premise, this could also be done phase by phase. If the voltage and current are steady the meter will not produce any event but if something unexpected happens, e.g. too high or low voltage, phase loss or 3-phase outage, the meter (or concentrator) will immediately generate events that could be used as alarms. These events are in general named Power Quality (PQ) and Power Outage (PO) events. The meter manufactures was early to understand the importance of the smart meters, it could in the future be used as a cheap sensor in the low voltage grid but the AMI infrastructure in general was not developed to handle these events in an efficient way and the network companies were not ready to use this new technic.

In Sweden the pressure from the regulator and the society, regarding improved quality of delivery, have given the smart metering infrastructure a new meaning for the DSO`s, a cheap tool for monitoring the low voltage grid. Traditional Scada systems monitor and control the grid down to and even the medium voltage level (normally 10-20 kV). Relays and breakers connected to the main control system through RTU´s gives the operator tools to manage the grid. The low voltage grid doesn´t have this kind of equipment and is normally protected by fuses and operated locally if the grid has to be disconnected. The operators in the main control center can´t today monitor the low voltage grid and the customers itself normally has to complain before any action can be taken.

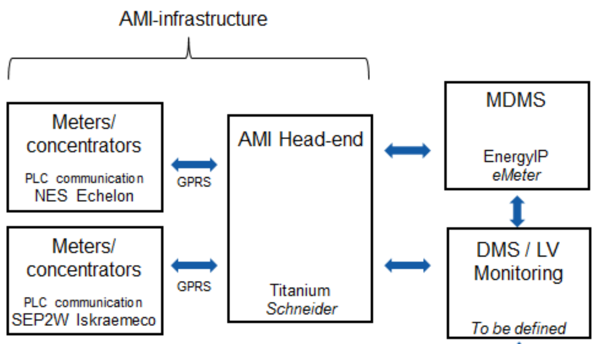
OBJECTIVES

Vattenfall is now in position to adapt the AMI-infrastructure to be used for monitoring the low voltage grid. As the AMI-infrastructure today is set-up for meter value collection the system as a whole does not meet the new requirements. The reason to use the AMI system for monitoring the low voltage grid is purely economically. Every secondary substation is equipped with an AMI data-concentrator operating locally with PLC communication to the Smart meters on the low voltage wires and cables. The data-concentrators are connected to the AMI Head-end through GPRS communication. The additional costs to adapt the AMI-system for monitoring the low voltage grid are extremely low compared with installing separately sensors on the outgoing low voltage feeders in the secondary substations.
The goal are to adapt the AMI-system regarding reliability, performance and response-times to meet the process requirements from operators in the grid control center and personal´s in Customer Service Center (CSC). From a customer point of view perspective the CSC organization as a first-line support should solve most of the questions. Today CSC does not have this kind of tool to meet customer's expectations of efficient treatment and correct information.
In the operation of HV- and MV-grids response-times normally means seconds or parts of minutes. The present response times for the AMI infrastructure are today extremely long. To meet the process needs functional requirements for incoming events from meters and data-concentrators the performance needs to be roughly >95% in 10 minutes. For querying a small group of meters (pinging) from operators / CSC the requirements needs to be <60 seconds.

CHALLANGES

Normally the metering and grid operations are completely separated business, different definitions, security issues, response times and technic. Using PLC communication with stated requirements of tens of minutes for events coming from the meters and 60 seconds to ping the meter will be a challenge. But as the alternative are much more complicated and expensive and the customers probably will see this service as good enough it will help the network company to fulfill their obligations in the future.
The AMI-infrastructure itself has to be more robust, reliable and faster. The PLC part of the system can suffer regarding high frequency noise on the grid from appliance at customers' home or industry and switched of meters (by customers). The polling mechanism, in the data-concentrator, could also have negative impact on the response time if there are too many meters per data-concentrator. To manage this kind of problems new methods needs to be developed.

Present outage events from the AMI data-concentrators needs to be filtered and quality assured, only reliable meter events should be forwarded to DMS and MDMS systems.



To give the operators, customer service personals and field-crew (entrepreneurs) possibility to monitor and understand what´s happening in the low voltage grid there is a need to integrate the AMI-infrastructure with the Low Voltage Monitoring interface in the DMS / Scada system solution. This will be a challenge regarding security issues as the systems are in different security zones.

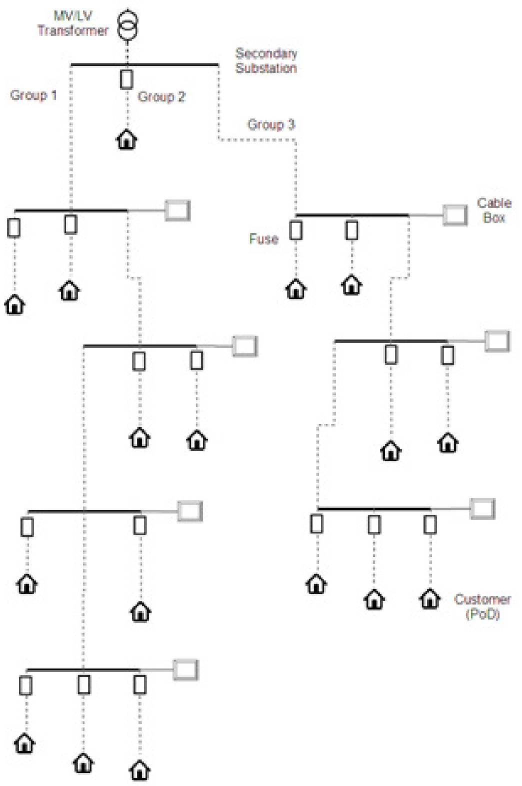


Figure 1. Example of LV grid.

GOAL AND DEVELOPMENTS

The plan is to establish low voltage grid monitoring based on the AMI-infrastructure in the next coming years. The Smart Grid Gotland project will be the platform to develop and test new functions. The goal is to establish automatically functions in the AMI Head-end system for continuously filtering and validating incoming power outage and power quality events as well as energy meter values from the smart meters.

The focus will initially be on developing new algorithms and filtering functions in the AMI Head-end system in order to quality assure the power outage events. As the power outage events, "meter down", in general not are trustworthy due to PLC noise problems and switched off meters the events needs to be validated based on the low voltage grid connectivity. When filtering the outage events it is essential that the grid connectivity is correct in the NIS system.

It is also important that performance and response-times are acceptable in the AMI communication system so the operators can identify outages in an acceptable short timeframe, for incoming events in <10 minutes.

The most critical thing is to secure that the grid connectivity is more or less correct. Normally the data in Network Information System (NIS) are correct but in some cases changes in the grid over the years has not been correctly up-dated in the NIS documentation. Especially rebuilding's or new grid sections could have been put in operations before it finally have been documented in NIS. If so the metering data events will not indicate power outages or power quality problems correctly. Therefor it is important to have a documentation process and system that is linked to the LV grid monitoring system in real-time or with very short delays so every switching activity in field can be identified in the operators presentation view and also be align with the smart meter information.

This new function for low voltage grid mapping (meters to identify the grid connectivity) is now under development at Vattenfall in the Smart Grid Gotland project. Using the smart metering system functionality to detecting signal to noise ratio for the PLC communication between the data-concentrator and the meters as well as between the meters it is possible to understand with high reliability under which data-concentrator (secondary substation) a meter is connected. This is working today in the AMI-system but is not used in practice in the back-end systems and processes.

With a new generation data-concentrators it will probably also be possible to detect on which low voltage feeder the meters are connected. This will also be tested in the Smart Grid Gotland project under the next coming years.

To have a good documentation quality in the NIS system is of importance when developing filtering functions in the metering system. The AMI Head-end will continuously be updated from the NIS data repository. In the same way will also AMI Head-end be updated with actual data from the data-concentrators regarding relationship to the meters. If there is a mismatch identified by the logic in the AMI Head-end it will be notified and reported back to the documentation department for updating the NIS system. The most trustworthy source for the filtering functions and algorithms in the AMI Head-end will in this case be the data-concentrators information.

All "meter down" events will be filtered and compared with the grid connectivity. If all meters below a cable-box (with fuses) have simultaneously "meter down" events the events will be defined as trustworthy and the events will be forwarded to the DMS- and MDMS systems and interpreted as power outages. If one of the meters is reachable all events will be rejected. The same procedure will be controlled by the algorithm regarding each LV feeder and the whole secondary substation. By this filtering function in the AMI Head-end untrusted “meter down” events from the AMI data-concentrator can be filtered out and be rejected. This will give Vattenfall a tool to identify power outages regardless of customer calls with high precision.

Based on this grid connectivity / topology identifier in the AMI Head-end system it is also possible to establish power quality and power flow control algorithms for continuously identifying unacceptable voltages levels or power flows. If installations of photovoltaic (PV) and charging of electrical cars (EV) will have negative impact on the quality of delivery algorithms will immediately identify were in the grid the problems are located. It is important to specify the thresholds for the algorithm, when an event should be generated or not. Typical thresholds for voltages could be >270 volts instantaneous, > 253 volts for more than 10 minutes or >253 volts/<207 volts unsymmetrical and regarding power > 90% of the transformers capacity.

A key issue is also to whom in the organization the unacceptable events should be addressed. Some of the events have the character of capacity problems and has to be handled by the planning department and others must be corrected immediately by a field crew at site.

CONCLUTIONS

The AMI-infrastructure can be a cheap tool to establish low voltage grid monitoring and give DSO´s possibility to deliver customers better service and improve the processes. This will reduce costs for customer service, field crew activities and make customers more satisfied with the service.